GDS Associates, Inc.
Engineers and Consultants

Michigan Electric And Natural Gas Energy Efficiency Potential Study

Final Report

Prepared for:

Michigan Public Service Commission

Consumers Energy
Count on Us

DTE Energy

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GDS Associates, Inc.
1850 Parkway Place
Suite 800
Marietta, GA 30067
770.425.8100
770.426.0303 (Fax)
www.gdsassociates.com

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1 EXECUTIVE SUMMARY

1.1 BACKGROUND

The Michigan Public Service Commission, DTE Energy and Consumers Energy worked together to complete this 2013 study of energy efficiency potential in the state of Michigan. This energy efficiency potential study provides a roadmap for policy makers and identifies the energy efficiency measures having the greatest potential savings and the measures that are the most cost effective. In addition to technical and economic potential estimates, the development of achievable potential estimates for a range of feasible energy efficiency measures is useful for program planning and modification purposes. Unlike achievable potential estimates, technical and economic potential estimates do not include customer acceptance considerations for energy efficiency measures, which are often among the most important factors when estimating the likely customer response to new programs. For this study, GDS Associates, the consulting firm retained to conduct this study, produced the following estimates of energy efficiency potential:

- Technical potential
- Economic potential
- Achievable potential

Definitions of the types of energy efficiency potential are provided below.

1. **TECHNICAL POTENTIAL** is the theoretical maximum amount of energy use that could be displaced by efficiency, disregarding all non-engineering constraints such as cost-effectiveness and the willingness of end-users to adopt the efficiency measures. It is often estimated as a "snapshot" in time assuming immediate implementation of all technologically feasible energy saving measures, with additional efficiency opportunities assumed as they arise from activities such as new construction.
2. **ECONOMIC POTENTIAL** refers to the subset of the technical potential that is economically cost-effective as compared to conventional supply-side energy resources. Both technical and economic potential are theoretical numbers that assume immediate implementation of efficiency measures, with no regard for the gradual "ramping up" process of real-life programs. In addition, they ignore market barriers to ensuring actual implementation of efficiency. Finally, they only consider the costs of efficiency measures themselves, ignoring any programmatic costs (e.g., marketing, analysis, administration) that would be necessary to capture them.
3. **ACHIEVABLE POTENTIAL** is the amount of energy use that efficiency can realistically be expected to displace assuming different market penetration scenarios for cost effective energy efficiency measures. An aggressive scenario, for example, could, provide program participants with payments for the entire incremental cost of more energy efficient equipment). This is often referred to as "maximum achievable potential". Achievable potential takes into account real-world barriers to convincing end-users to adopt cost effective energy efficiency measures, the non-measure costs of delivering programs (for administration, marketing, tracking systems, monitoring and evaluation, etc.), and the capability of programs and administrators to ramp up program activity over time.[1] Achievable savings potential savings is a subset of economic potential.

This potential study evaluates three achievable potential scenarios:

1) **Scenario #1**: For the first scenario, achievable potential represents the amount of energy use that efficiency can realistically be expected to displace assuming incentives equal to 50% of the

[1] These definitions are from the November 2007 National Action Plan for Energy Efficiency "Guide for Conducting Energy Efficiency Potential Studies"

incremental measure cost and no spending cap. Cost effectiveness of measures was determined with the Utility Cost Test.

2) **Scenario #2**: For the second scenario, achievable potential is based on measure cost effectiveness screening using the Total Resource Cost Test with utility incentives again equal to 50% of measure costs.
3) **Scenario #3**: The third scenario is a subset of Achievable Scenario #1(based on UCT). While scenario #1 assumed no spending cap on efficiency measures, Achievable Scenario #3 assumed a spending cap of approximately 2% of annual utility revenues. The third scenario assumes a spending cap of 2% of annual utility revenue in order to align the scenario with the existing legislation in the state of Michigan. According to Public Act 295 of 2008, gas and electric utilities are not permitted (without specific approval from the Commission) to spend more than 2.0% of retail sales in attempting to comply with the energy optimization performance standard.

The purpose of this energy efficiency potential study is to provide a foundation for the continuation of utility-administered energy efficiency programs in Michigan and to determine the remaining opportunities for cost effective electricity and natural gas energy efficiency savings for the state of Michigan. This detailed report presents results of the technical, economic, and achievable potential for electric and natural gas efficiency measures in Michigan for two time periods:

- The five-year period from January 1, 2014 through December 31, 2018
- The ten-year period from January 1, 2014 through December 31, 2023

All results were developed using customized residential, commercial and industrial sector-level potential assessment analytic models and Michigan-specific cost effectiveness criteria including the most recent Michigan-specific avoided cost projections for electricity and natural gas. To help inform these energy efficiency potential models, up-to-date energy efficiency measure data were primarily obtained from the following recent studies and reports:

1) Michigan Energy Measures Database (MEMD)
2) Energy efficiency baseline studies conducted by DTE Energy and Consumers Energy
3) 2009 EIA Residential Energy Consumption Survey (RECS)
4) 2007 American Housing Survey (AHS)
5) 2003 EIA Commercial Building Energy Consumption Survey (CBECS)[2]

The above data sources provided valuable information regarding the current saturation, costs, savings and useful lives of electric and natural gas energy efficiency measures considered in this study.

The results of this study provide detailed information on energy efficiency measures that are the most cost effective and have the greatest potential electric and natural gas savings for the State of Michigan. The data used for this report were the best available at the time this analysis was developed. As building and appliance codes and energy efficiency standards change, and as energy prices fluctuate, additional opportunities for energy efficiency may occur while current practices may become outdated.

1.2 STUDY SCOPE

The study examines the potential to reduce electric consumption and peak demand and natural gas consumption through the implementation of energy efficiency technologies and practices in residential, commercial, and industrial facilities in Michigan. This study assesses electric and natural gas energy efficiency potential in Michigan over ten years, from 2014 through 2023.

The study had the following main objectives:

[2] This is the latest publicly available CBECS data released by the Energy Information Administration (EIA).

- Evaluate the electric and natural gas energy efficiency technical, economic and achievable potential savings in the State of Michigan;
- Calculate the economic and achievable potential energy efficiency savings based upon cost effectiveness screening with both the TRC and UCT benefit/cost ratios.

As noted above, the scope of this study distinguishes among three types of energy efficiency potential; (1) technical, (2) economic, and (3) achievable potential. The definitions used in this study for energy efficiency potential estimates were obtained directly from a 2007 National Action Plan for Energy Efficiency (NAPEE) report. Figure 1-1 below provides a graphical representation of the relationship of the various definitions of energy efficiency potential.

Figure 1-1: Types of Energy Efficiency Potential[3]

Not Technically Feasable	Technical Potential		
Not Technically Feasable	Not Cost Effective	Economic Potential	
Not Technically Feasable	Not Cost Effective	Market & Adoption Barriers	Achievable Potential

Limitations to the scope of study: As with any assessment of energy efficiency potential, this study necessarily builds on a large number of assumptions and data sources, including the following:

- Energy efficiency measure lives, measure savings and measure costs
- The discount rate for determining the net present value of future savings
- Projected penetration rates for energy efficiency measures
- Projections of Michigan specific electric and natural gas avoided costs
- Future changes to current energy efficiency codes and standards for buildings and equipment

While the GDS Team has sought to use the best and most current available data, there are many assumptions where there may be reasonable alternative assumptions that would yield somewhat different results. Furthermore, while the lists of energy efficiency measures examined in this study represent most commercially available measures, these measure lists are not exhaustive.

With respect to non-energy benefits of energy efficiency programs, GDS did include an adder of $9.25 per ton of carbon for reduced emissions of CO2. This is the expected value for reduced carbon emissions based upon equal weighting of a scenario with no carbon taxes and a scenario where a carbon tax of $18.50 per ton is implemented in the future.

Finally there was no attempt to place a dollar value on some difficult to quantify benefits arising from installation of some measures, such as increased comfort or increased safety, which may in turn support some personal choices to implement particular measures that may otherwise not be cost-effective or only marginally so.

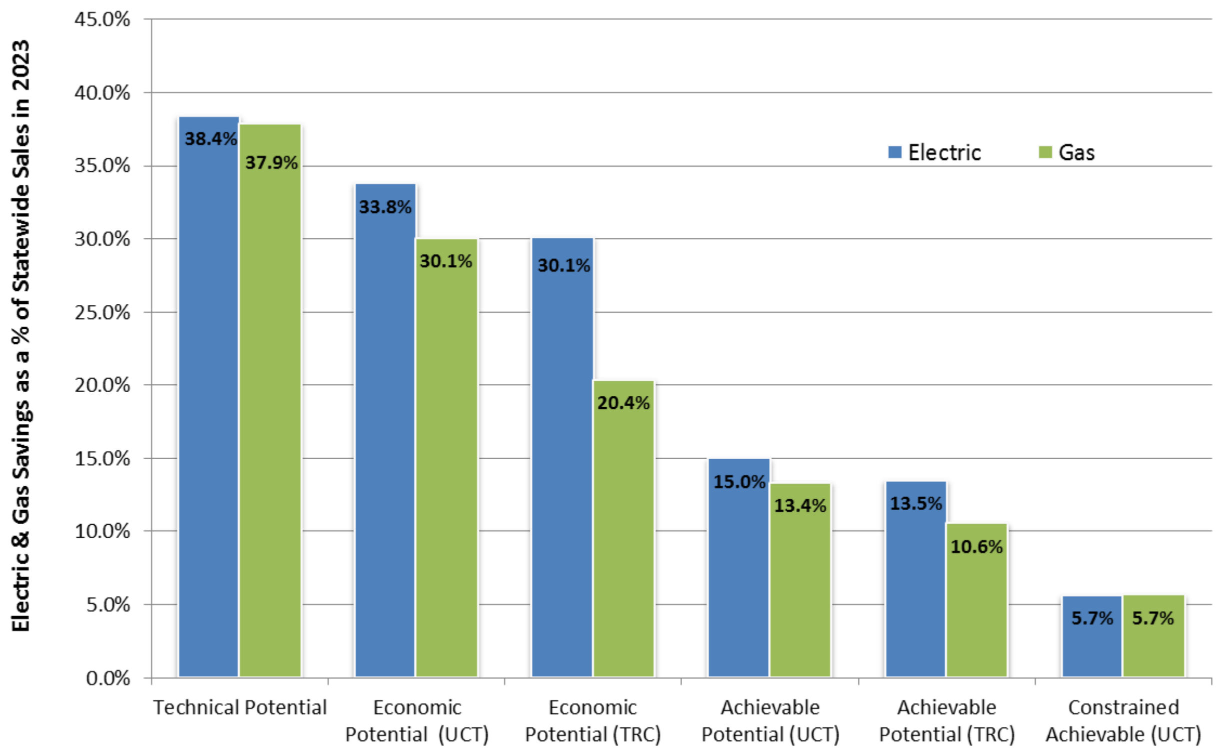
1.3 SUMMARY OF RESULTS

This study examined 1,417 electric energy efficiency measures and 922 natural gas measures in the residential, commercial and industrial sectors combined.

[3] Reproduced from "Guide to Resource Planning with Energy Efficiency" November 2007. US EPA. Figure 2-1.

Figure 1-2 below shows that cost effective electric energy efficiency resources can play a significantly expanded role in Michigan's energy resource mix over the next five and ten years. For the State of Michigan overall, the achievable potential for electricity savings based on the UCT in 2023 is 15.0% of forecast kWh sales for 2023. For the State overall, the achievable potential for natural gas savings based on the UCT in 2023 is also 13.4% of forecast MMBtu sales for 2023.

Figure 1-2: Electric & Gas Energy Efficiency Potential Savings Summary



Tables 1-1 and 1-2 present additional detail, providing the energy efficiency savings potential for all scenarios over a period of 5 and 10 years, respectively.

Table 1-1: Summary of Technical, Economic and Achievable Electric and Gas Energy Savings for 2018

END USE	TECHNICAL POTENTIAL	ECONOMIC POTENTIAL (UCT)	ECONOMIC POTENTIAL (TRC)	ACHIEVABLE POTENTIAL (UCT)	ACHIEVABLE POTENTIAL (TRC)	CONSTRAINED ACHIEVABLE (UCT)
Electric Sales MWh						
Savings % - Residential	45.8%	41.3%	39.8%	10.7%	10.5%	4.3%
Savings % - Commercial	48.5%	44.9%	37.4%	12.2%	10.5%	3.1%
Savings % - Industrial	27.0%	21.0%	19.3%	4.9%	4.5%	2.3%
Savings % - Total	**40.7%**	**36.1%**	**32.4%**	**9.4%**	**8.6%**	**3.2%**
Savings mWh - Residential	15,481,730	13,967,946	13,466,463	3,622,394	3,549,596	1,465,036
Savings mWh -	18,525,217	17,186,647	14,282,862	4,651,994	4,004,548	1,188,821

END USE	TECHNICAL POTENTIAL	ECONOMIC POTENTIAL (UCT)	ECONOMIC POTENTIAL (TRC)	ACHIEVABLE POTENTIAL (UCT)	ACHIEVABLE POTENTIAL (TRC)	CONSTRAINED ACHIEVABLE (UCT)
Commercial						
Savings mWh - Industrial	9,180,717	7,133,458	6,568,017	1,674,490	1,537,639	785,903
Savings mWh - Total	**43,187,664**	**38,288,051**	**34,317,341**	**9,948,878**	**9,091,783**	**3,439,760**
Electric Demand MW						
Savings % - Residential	42.7%	38.9%	41.0%	8.4%	8.9%	3.4%
Savings % - Commercial	53.8%	49.9%	42.3%	12.2%	10.6%	3.1%
Savings % - Industrial	40.6%	30.8%	27.4%	6.7%	6.3%	3.1%
Savings % - Total	**47.0%**	**42.1%**	**39.2%**	**9.7%**	**9.2%**	**3.2%**
Savings MW - Residential	4,274	3,895	4,106	839	892	340
Savings MW - Commercial	5,715	5,300	4,496	1,292	1,127	334
Savings MW - Industrial	1,790	1,360	1210	296	278.5	138
Savings MW - Total	**11,779**	**10,555**	**9,812**	**2,426**	**2,298**	**812**
Natural Gas Sales MMBtu						
Savings % - Residential	45.9%	34.8%	19.4%	9.4%	7.1%	3.8%
Savings % - Commercial	34.6%	29.8%	24.2%	6.1%	5.4%	3.1%
Savings % - Industrial	16.1%	13.0%	12.1%	2.7%	2.5%	0.7%
Savings % - Total	**35.2%**	**27.8%**	**18.8%**	**6.8%**	**5.5%**	**2.8%**
Savings MMBtu - Residential	136,706,666	103,587,007	57,885,592	27,930,065	21,296,093	11,332,060
Savings MMBtu - Commercial	58,904,392	50,760,002	41,188,176	10,382,936	9,274,379	5,309,780
Savings MMBtu - Industrial	26,183,022	21,190,526	19,611,597	4,451,220	3,986,192	1,070,312
Savings MMBtu - Total	**221,794,080**	**175,537,535**	**118,685,365**	**42,764,221**	**34,556,665**	**17,712,153**

Table 1-2: Summary of Technical, Economic and Achievable Electric and Gas Energy Savings for 2023

End Use	Technical Potential	Economic Potential (UCT)	Economic Potential (TRC)	Achievable Potential (UCT)	Achievable Potential (TRC)	Constrained Achievable (UCT)
Electric Sales MWh						
Savings % - Residential	39.7%	35.2%	33.7%	14.7%	14.3%	5.9%
Savings % - Commercial	48.0%	44.5%	37.0%	20.8%	17.6%	6.0%
Savings % - Industrial	26.4%	20.5%	18.9%	8.9%	8.1%	5.0%
Savings % - Total	**38.4%**	**33.8%**	**30.1%**	**15.0%**	**13.5%**	**5.7%**
Savings mWh - Residential	13,697,929	12,146,247	11,644,006	5,070,834	4,946,942	2,044,561
Savings mWh - Commercial	18,601,147	17,251,862	14,344,326	8,057,699	6,835,102	2,326,054
Savings mWh - Industrial	9,180,717	7,133,458	6,568,017	3,087,742	2,816,429	1,735,830
Savings mWh - Total	**41,479,793**	**36,531,567**	**32,556,350**	**16,216,275**	**14,598,473**	**6,106,445**
Electric Demand MW						
Savings % - Residential	40.5%	36.7%	38.9%	13.1%	14.1%	5.3%
Savings % - Commercial	53.2%	49.3%	41.9%	22.6%	19.7%	6.8%
Savings % - Industrial	39.7%	30.2%	26.9%	12.7%	12.0%	7.4%
Savings % - Total	**45.7%**	**40.9%**	**38.0%**	**17.0%**	**16.1%**	**6.3%**
Savings MW - Residential	4,138	3,758	3,980	1,338	1,447	540
Savings MW - Commercial	5,741	5,325	4,519	2,433	2,128	737
Savings MW - Industrial	1,790	1,360	1210	571	539.2	335
Savings MW - Total	**11,669**	**10,442**	**9,709**	**4,342**	**4,114**	**1,613**
Natural Gas Sales MMBtu						
Savings % - Residential	51.0%	38.9%	22.1%	18.9%	14.0%	7.7%
Savings % - Commercial	34.9%	30.1%	24.4%	12.3%	11.0%	6.3%
Savings % - Industrial	17.1%	13.8%	12.8%	4.4%	3.9%	1.3%
Savings % - Total	**37.9%**	**30.1%**	**20.4%**	**13.4%**	**10.6%**	**5.7%**
Savings MMBtu - Residential	143,271,591	109,298,652	62,091,152	53,178,705	39,326,470	21,495,414
Savings MMBtu - Commercial	59,047,573	50,950,115	41,298,436	20,766,093	18,548,759	10,743,415
Savings MMBtu -	26,183,022	21,190,526	19,611,597	6,677,438	6,013,211	2,038,818

END USE	TECHNICAL POTENTIAL	ECONOMIC POTENTIAL (UCT)	ECONOMIC POTENTIAL (TRC)	ACHIEVABLE POTENTIAL (UCT)	ACHIEVABLE POTENTIAL (TRC)	CONSTRAINED ACHIEVABLE (UCT)
Industrial						
Savings MMBtu - Total	**228,502,186**	**181,439,293**	**123,001,185**	**80,622,236**	**63,888,440**	**34,277,647**

Last, the five-year and ten-year budgets and acquisition costs for the achievable potential scenarios for electric and natural gas energy efficiency savings are shown in Table 1-3 and 1-4.

GDS is providing the information on the projected acquisition per first year unit of energy saved in order to provide program planners and decision-makers with the expected cost to utilities to acquire the electric and natural gas savings for the three achievable potential scenarios examined in this report. It is important for program planners and other decision-makers to have a good understanding of the cost to utilities to acquire these levels of energy efficiency savings.

Table 1-3: Achievable Potential Scenarios; Budgets and Acquisition Costs Per Unit of Energy Saved – Electric Savings (Budgets Are Not in Present Value Dollars)

ALL SECTORS COMBINED	5 - YEAR EE BUDGET	10-YEAR EE BUDGET	ACQUISITION COST PER FIRST YEAR KWH SAVED - 5 YEARS	ACQUISITION COST PER FIRST YEAR KWH SAVED - 10 YEARS
Achievable UCT	$2,644,861,311	$5,019,681,110	$0.24	$0.22
Achievable TRC	$1,678,655,015	$3,285,131,139	$0.16	$0.16
Constrained UCT	$860,355,319	$1,774,960,027	$0.22	$0.20

Table 1-4: Achievable Potential Scenarios; Budgets and Acquisition Costs Per Unit of Energy Saved – Natural Gas Savings (Budgets Are Not in Present Value Dollars)

ALL SECTORS COMBINED	5 - YEAR EE BUDGET	10-YEAR EE BUDGET	ACQUISITION COST PER FIRST YEAR MMBTU SAVED - 5 YEARS	ACQUISITION COST PER FIRST YEAR MMBTU SAVED - 10 YEARS
Achievable UCT	$1,256,502,449	$2,506,262,004	$26.37	$25.57
Achievable TRC	$698,817,669	$1,395,301,521	$17.56	$16.86
Constrained UCT	$506,943,484	$1,031,893,201	$25.87	$24.92

Table 1-5 presents the sum of the utility energy efficiency budgets (not present valued) for five and ten years for each achievable potential scenario for electric and natural gas measures combined. The net present value budgets for five and ten years are provided in Tables 1-9 and 1-10.

Table 1-5: Achievable Potential Scenarios; Total Budgets for Electric and Natural Gas Savings Combined (Budgets Are Not in Present Value Dollars)

ALL SECTORS COMBINED	5 - YEAR EE BUDGET	10-YEAR EE BUDGET
Achievable UCT	$3,901,363,759	$7,525,943,114
Achievable TRC	$2,377,472,684	$4,680,432,660
Constrained UCT	$1,367,298,803	$2,806,853,228

Tables 1-6, 1-7 and 1-8 present the annual utility budgets in total and by sector required to achieve the savings levels in each achievable potential scenario. These tables also present annual information on the percent of annual utility revenues needed each year to fund acquiring the energy savings levels for each achievable potential scenario.

Table 1-6: Annual Program Budgets Associated with the Achievable UCT Scenario (in millions)

	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Residential	$310.3	$335.5	$339.7	$343.3	$344.6	$345.8	$345.6	$346.9	$346.1	$345.3
Commercial	$299.8	$363.6	$367.5	$367.6	$311.8	$318.5	$293.3	$298.1	$308.0	$307.0
Industrial	$72.4	$107.8	$125.1	$124.5	$87.7	$88.0	$69.4	$69.5	$70.4	$72.8
Total Budgets	***$682.5***	***$807.0***	***$832.4***	***$835.4***	***$744.1***	***$752.2***	**$708.3**	**$714.5**	**$724.5**	**$725.1**
% of Annual Revenue	*5.1%*	*6.0%*	*6.1%*	*6.1%*	*5.3%*	*5.3%*	*5.0%*	*5.0%*	*5.0%*	*4.9%*

Table 1-7: Annual Program Budgets Associated with the Achievable TRC Scenario (in millions)

	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Residential	$211.2	$236.4	$239.8	$242.6	$243.1	$243.7	$243.0	$243.8	$242.7	$241.7
Commercial	$138.8	$182.3	$198.1	$198.2	$162.8	$168.9	$152.9	$157.3	$166.2	$166.3
Industrial	$50.4	$66.2	$74.2	$74.3	$59.1	$59.6	$55.5	$52.0	$53.1	$56.2
Total Budgets	***$400.4***	***$484.9***	***$512.1***	***$515.0***	***$465.0***	***$472.2***	**$451.3**	**$453.1**	**$462.1**	**$464.2**
% of Annual Revenue	*3.0%*	*3.6%*	*3.8%*	*3.7%*	*3.3%*	*3.4%*	*3.2%*	*3.1%*	*3.2%*	*3.2%*

Table 1-8: Annual Program Budgets Associated with the Constrained UCT Scenario (in millions)

	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Residential	$136.3	$135.2	$135.5	$136.3	$137.0	$137.8	$138.6	$139.4	$140.2	$141.0
Commercial	$92.8	$93.7	$95.4	$96.9	$98.4	$100.0	$101.6	$103.2	$104.9	$106.5
Industrial	$40.7	$41.2	$42.0	$42.7	$43.2	$43.9	$44.5	$45.2	$46.0	$46.7
Total Budgets	***$269.8***	***$270.1***	***$272.9***	***$275.8***	***$278.7***	***$281.7***	**$284.7**	**$287.8**	**$291.0**	**$294.2**
% of Annual Revenue	*2.0%*	*2.0%*	*2.0%*	*2.0%*	*2.0%*	*2.0%*	*2.0%*	*2.0%*	*2.0%*	*2.0%*

1.4 ENERGY EFFICIENCY POTENTIAL SAVINGS DETAIL BY SECTOR

Note that Sections 6, 7 and 8 of this report include additional detail about the electric and natural gas energy efficiency savings potential in Michigan by 2023.

1.5 COST EFFECTIVENESS FINDINGS

This study examines economic potential scenarios using the Total Resource Cost (TRC) test and the Utility Cost Test (UCT). This energy efficiency potential study concludes that significant cost effective electric and natural gas energy efficiency potential remains in in Michigan. Tables 1-9 and 1-10 show the preliminary present value benefits, costs and benefit-cost ratios for the Achievable Potential scenarios examined in this study.

Table 1-9: Benefit-Cost Ratios for Achievable Potential Scenarios For 2014 to 2018 Time Period

ACHIEVABLE POTENTIAL SCENARIOS	NPV $ BENEFITS	NPV $ COSTS	BENEFIT/COST RATIO	NET BENEFITS
Achievable UCT	$8,819,456,909	$3,452,121,731	2.55	$5,367,335,178
Achievable TRC	$9,090,916,601	$3,542,860,326	2.57	$5,548,056,275
Constrained UCT	$3,134,114,985	$1,212,231,599	2.59	$1,921,883,386

Table 1-10: Benefit-Cost Ratios for Achievable Potential Scenarios For 2014 to 2023 Time Period

ACHIEVABLE POTENTIAL SCENARIOS	NPV $ BENEFITS	NPV $ COSTS	BENEFIT/COST RATIO	NET BENEFITS
Achievable UCT	$15,854,685,097	$5,807,771,171	2.73	$10,046,913,925
Achievable TRC	$16,434,033,885	$6,063,428,268	2.71	$10,370,605,616
Constrained UCT	$5,996,092,253	$2,145,524,086	2.79	$3,850,568,167

In addition, GDS did calculate TRC and UCT benefit/cost ratios for each individual energy efficiency measure considered in this study. Only measures that had a benefit/cost ratio greater than or equal to 1.0 were retained in the economic and achievable potential savings estimates. It is important to note that energy efficiency measures for low income households do not need to be cost effective in Michigan. However, for consistency in this report, GDS has excluded all non-cost effective measures from estimates of economic and achievable potential energy efficiency savings.

1.6 REPORT ORGANIZATION

The remainder of this report is organized as follows:

Section 2: Glossary of Terms defines key terminology used in the report.

Section 3: Introduction highlights the purpose of this study and the importance of energy efficiency.

Section 4: Characterization of Electric and Natural Gas Energy Consumption in Michigan provides an overview of the economic/demographic characteristics of Michigan and a brief discussion of the historical and forecasted electric and natural gas energy sales by sector as well as electric peak demand.

Section 5: Potential Study Methodology details the approach used to develop the estimates of technical, economic and achievable potential savings for electric and natural gas energy efficiency savings.

Section 6: Residential Electric and Natural Gas Energy Efficiency Potential Estimates (2013-2022) provides a breakdown of the technical, economic, and achievable energy efficiency savings potential in the residential sector.

Section 7: Commercial Sector Electric and Natural Gas Energy Efficiency Potential Estimates (2014-2023) provides a breakdown of the technical, economic, and achievable energy efficiency savings potential in the commercial sector.

Section 8: Industrial Sector Electric and Natural Gas Energy Efficiency Potential Estimates (2014-2023) provides a breakdown of the technical, economic, and achievable energy efficiency savings potential in the industrial sector.

2 GLOSSARY OF TERMS[4]

The following list defines many of the key energy efficiency terms used throughout this energy efficiency potential study.

ACHIEVABLE POTENTIAL: The November 2007 National Action Plan for Energy Efficiency "Guide for Conducting Energy Efficiency Potential Studies" defines achievable potential as the amount of energy use that energy efficiency can realistically be expected to displace assuming the most aggressive program scenario possible (*e.g.*, providing end-users with payments for the entire incremental cost of more efficient equipment). This is often referred to as maximum achievable potential. Achievable potential takes into account real-world barriers to convincing end-users to adopt efficiency measures, the non-measure costs of delivering programs (for administration, marketing, tracking systems, monitoring and evaluation, etc.), and the capability of programs and administrators to ramp up program activity over time.

APPLICABILITY FACTOR: The fraction of the applicable housing units or businesses that is technically feasible for conversion to the efficient technology from an engineering perspective (e.g., it may not be possible to install CFLs in all light sockets in a home because the CFLs may not fit in every socket in a home).

AVOIDED COSTS: For purposes of this report, the electric avoided costs are defined as the generation, transmission and distribution costs that can be avoided in the future if the consumption of electricity or natural gas can be reduced with energy efficiency or demand response programs. For a natural gas utility, the avoided costs include the cost of the natural gas commodity and any other natural gas infrastructure costs that can be reduced with energy efficiency programs.

BASE ACHIEVABLE POTENTIAL: For purposes of this study, an achievable potential scenario which assumes incentives are set to 50% of the incremental or full measure cost.

BASE CASE EQUIPMENT END-USE INTENSITY: The electricity or natural gas used per customer per year by each base-case technology in each market segment. This is the consumption of the electric or natural gas energy using equipment that the efficient technology replaces or affects. For example, if the efficient measure is a high efficiency light bulb (CFL), the base end-use intensity would be the annual kWh use per bulb per household associated with an incandescent or halogen light bulb that provides equivalent lumens to the CFL.

BASE CASE FACTOR: The fraction of the market that is applicable for the efficient technology in a given market segment. For example, for the residential electric clothes washer measure, this would be the fraction of all residential customers that have an electric clothes washer in their household.

CAPITAL RECOVERY RATE (CRR): The return of invested capital expressed as an annual rate; often applied in a physical sense to wasting assets with a finite economic life.[5]

COINCIDENCE FACTOR: The fraction of connected load expected to be "on" and using electricity coincident with the electric system peak period.

CONSTRAINED ACHIEVABLE: An achievable potential scenario which assumes a lower level of incentives or lower annual program budgets than in the base case scenario.

[4] Potential definitions taken from National Action Plan for Energy Efficiency (2007). "Guide for Conducting Energy Efficiency Potential Studies." Prepared by Philip Mosenthal and Jeffrey Loiter, Optimal Energy, Inc.
[5] Accuval. http://www.accuval.net/insights/glossary/

COST-EFFECTIVENESS: A measure of the relevant economic effects resulting from the implementation of an energy efficiency measure or program. If the benefits are greater than the costs, the measure is said to be cost-effective.

CUMULATIVE ANNUAL: Refers to the overall annual savings occurring in a given year from both new participants and annual savings continuing to result from past participation with energy efficiency measures that are still in place. Cumulative annual does not always equal the sum of all prior year incremental values as some energy efficiency measures have relatively short lives and, as a result, their savings drop off over time.

COMMERCIAL SECTOR: Comprised of non-manufacturing premises typically used to sell a product or provide a service, where electricity is consumed primarily for lighting, space cooling and heating, office equipment, refrigeration and other end uses. Business types are included in Section 5 – Methodology.

DEMAND RESPONSE: Refers to electric demand resources involving dynamic hourly load response to market conditions, such as curtailment or load control programs.

EARLY REPLACEMENT: Refers to an energy efficiency measure or efficiency program that seeks to encourage the replacement of functional equipment before the end of its operating life with higher-efficiency units.

ECONOMIC POTENTIAL: The November 2007 National Action Plan for Energy Efficiency "Guide for Conducting Energy Efficiency Potential Studies" refers to the subset of the technical potential that is economically cost-effective as compared to conventional supply-side energy resources as economic potential. Both technical and economic potential are theoretical numbers that assume immediate implementation of efficiency measures, with no regard for the gradual "ramping up" process of real-life programs. In addition, they ignore market barriers to ensuring actual implementation of efficiency. Finally, they only consider the costs of efficiency measures themselves, ignoring any programmatic costs (e.g., marketing, analysis, administration, evaluation) that would be necessary to capture them.

END-USE: A category of equipment or service that consumes energy (*e.g.*, lighting, refrigeration, heating, process heat, cooling).

ENERGY EFFICIENCY: Using less energy to provide the same or an improved level of service to the energy consumer in an economically efficient way. Sometimes "conservation" is used as a synonym, but that term is usually taken to mean using less of a resource even if this results in a lower service level (*e.g.*, setting a thermostat lower or reducing lighting levels).

ENERGY USE INTENSITY (EUI): A unit of measurement that describes a building's energy use. EUI represents the energy consumed by a building relative to its size.[6]

FREE DRIVER: Individuals or businesses that adopt an energy efficient product or service because of an energy efficiency program, but are difficult to identify either because they do not receive an incentive or are not aware of the program.

FREE RIDER: Participants in an energy efficiency program who would have adopted an energy efficiency technology or improvement in the absence of a program or financial incentive.

[6] See http://www.energystar.gov/index.cfm?fuseaction=buildingcontest.eui

GROSS SAVINGS: Gross energy (or demand) savings are the change in energy consumption or demand that results directly from program-promoted actions (e.g., installing energy-efficient lighting) taken by program participants regardless of the extent or nature of program influence on their actions.

INCENTIVE COSTS: A rebate or some form of payment used to encourage people to implement a given demand-side management (DSM) technology.

INCREMENTAL: Savings or costs in a given year associated only with new installations of energy efficiency or demand response measures happening in that specific year.

INDUSTRIAL SECTOR: Comprised of manufacturing premises typically used for producing and processing goods, where electricity is consumed primarily for operating motors, process cooling and heating, and space heating, ventilation, and air conditioning (HVAC). Business types are included in section 5 – Methodology.

MAXIMUM (OR MAX) ACHIEVABLE: An achievable potential scenario which assumes incentives for program participants are equal to 100% of measure incremental or full costs.

MEASURE: Any action taken to increase energy efficiency, whether through changes in equipment, changes to a building shell, implementation of control strategies, or changes in consumer behavior. Examples are higher-efficiency central air conditioners, occupancy sensor control of lighting, and retro-commissioning. In some cases, bundles of technologies or practices may be modeled as single measures. For example, an ENERGY STAR® ™ home package may be treated as a single measure.

MMBTU: A measure of power, used in this report to refer to consumption and savings associated with natural gas consuming equipment. One British thermal unit (symbol Btu or sometimes BTU) is a traditional unit of energy equal to about 1055 joules. It is the amount of energy needed to heat one pound of water by one degree Fahrenheit. MMBtu is defined as one million BTUs.

MW: A unit of electrical output, equal to one million watts or one thousand kilowatts. It is typically used to refer to the output of a power plant.

MWH: One thousand kilowatt-hours, or one million watt-hours. One MWh is equal to the use of 1,000,000 watts of power in one hour.

NET-TO-GROSS RATIO: A factor representing net program savings divided by gross program savings that is applied to gross program impacts to convert them into net program load impacts

NET SAVINGS: Net energy or demand savings refer to the portion of gross savings that is attributable to the program. This involves separating out the impacts that are a result of other influences, such as consumer self-motivation. Given the range of influences on consumers' energy consumption, attributing changes to one cause (i.e., a particular program) or another can be quite complex.

NON INCENTIVE COST: Costs incurred by the utility that do not include incentives paid to the customer (i.e.: program administrative costs, program marketing costs, data tracking and reporting, program evaluation, etc.)

NONPARTICIPANT SPILLOVER: Savings from efficiency projects implemented by those who did not directly participate in a program, but which nonetheless occurred due to the influence of the program.

PARTICIPANT COST: The cost to the participant to participate in an energy efficiency program.

PARTICIPANT SPILLOVER: Additional energy efficiency actions taken by program participants as a result of program influence, but actions that go beyond those directly subsidized or required by the program.[7]

PORTFOLIO: Either a collection of similar programs addressing the same market, technology, or mechanisms; or the set of all programs conducted by one energy efficiency organization or utility.

PROGRAM: A mechanism for encouraging energy efficiency that may be funded by a variety of sources and pursued by a wide range of approaches (typically includes multiple energy efficiency measures).

PROGRAM POTENTIAL: The November 2007 National Action Plan for Energy Efficiency 'Guide for Conducting Energy Efficiency Potential Studies" refers to the efficiency potential possible given specific program funding levels and designs as program potential. Often, program potential studies are referred to as "achievable" in contrast to "maximum achievable." In effect, they estimate the achievable potential from a given set of programs and funding. Program potential studies can consider scenarios ranging from a single program to a full portfolio of programs. A typical potential study may report a range of results based on different program funding levels.

REMAINING FACTOR: The fraction of applicable units that have not yet been converted to the electric or natural gas energy efficiency measure; that is, one minus the fraction of units that already have the energy efficiency measure installed.

REPLACE-ON-BURNOUT: An energy efficiency measure is not implemented until the existing technology it is replacing fails or burns out. An example would be an energy efficient water heater being purchased after the failure of the existing water heater at the end of its useful life.

RESOURCE ACQUISITION COSTS: The cost of energy savings associated with energy efficiency programs, generally expressed in costs per first year or per lifetime MWH saved ($/MWh), kWh ($/kWh), or MMBtu ($/MMBtu) in this report.

RETROFIT: Refers to an efficiency measure or efficiency program that seeks to encourage the replacement of functional equipment before the end of its operating life with higher-efficiency units (also called "early retirement") or the installation of additional controls, equipment, or materials in existing facilities for purposes of reducing energy consumption (e.g., increased insulation, low flow devices, lighting occupancy controls, economizer ventilation systems).

SAVINGS FACTOR: The percentage reduction in electricity or natural gas consumption resulting from application of the efficient technology. The savings factor is used in the formulas to calculate energy efficiency potential.

SOCIETAL COST TEST: Measures the net benefits of the energy efficiency program for a region or service area as a whole. Costs included in the SCT are costs to purchase and install the energy efficiency measure and overhead costs of running the energy efficiency program. The SCT may also include non-energy costs, such as reduced customer comfort levels. The benefits included are the avoided costs of energy and capacity, plus environmental and other non-energy benefits that are not currently valued by the market.

TECHNICAL POTENTIAL: The theoretical maximum amount of energy use that could be displaced by energy efficiency, disregarding all non-engineering constraints such as cost-effectiveness and the willingness of end-users to adopt the energy efficiency measures. It is often estimated as a "snapshot" in

[7] The definitions of participant and nonparticipant spillover were obtained from the National Action Plan for Energy Efficiency Report titled "Model Energy Efficiency Program Impact Evaluation Guide", November 2007, page ES-4.

time assuming immediate implementation of all technologically feasible energy saving measures, with additional efficiency opportunities assumed as they arise from activities such as new construction.

TOTAL RESOURCE COST TEST: The TRC measures the net benefits of the energy efficiency program for a region or service area as a whole from the combined perspective of the utility and program participants. Costs included in the TRC are costs to purchase and install the energy efficiency measure and overhead costs of running the energy efficiency program. Costs include all costs for the utility and the participants. The benefits included are the avoided costs of energy and capacity plus any quantifiable non-energy benefits (such as reduced emissions of carbon dioxide).

UTILITY COST TEST: The UCT measures the net benefits of the energy efficiency program for a region or service area as a whole from the utility's perspective. Costs included in the UCT are the utility's costs to design, implement and evaluate a program. The benefits included are the avoided costs of energy and capacity.

3 INTRODUCTION

This report assesses the potential for electric and natural gas energy efficiency programs to assist Michigan in meeting future energy service needs. This section of the report provides the following information:

- Defines the term "energy efficiency";
- Describes the general benefits of energy efficiency programs;
- Provides results of similar energy efficiency potential studies conducted in other states; and,
- Describes contents of the Sections of this report.

The purpose of this energy efficiency potential study is to provide a detailed assessment of the technical, economic and achievable potential for electric and natural gas energy efficiency Michigan. This study has examined a full array of energy efficiency technologies and energy efficient building practices that are technically achievable. The results of this study can be used to develop energy efficiency goals for Michigan in the short and long-term. The strategies that will be developed based on this potential study will guide direction and scope of utility administered energy efficiency programs in reducing electric and natural gas energy consumption in Michigan.

3.1 INTRODUCTION TO ENERGY EFFICIENCY

Efficient energy use, often referred to as energy efficiency, is using less energy to provide the same level of energy service. An example would be insulating a home or business in order to use less heating and cooling energy to achieve the same inside temperature. Another example would be installing fluorescent lighting in place of less efficient halogen or incandescent lights to attain the same level of illumination. Energy efficiency can be achieved through more efficient technologies and/or processes as well as through changes in individual behavior.

3.1.1 General Benefits of Energy Efficiency

There are a number of benefits that accrue to the State of Michigan due to electric and natural gas energy efficiency programs. These benefits include avoided cost savings, non-electric benefits such as water and fossil fuel savings, environmental benefits, economic stimulus, job creation, risk reduction, and energy security.

Avoided electric energy and capacity costs are based upon the costs an electric utility would incur to construct and operate new electric power plants or to purchase power from another source. These avoided costs of electricity include both fixed and variable costs that can be directly avoided through a reduction in electricity usage. The energy component includes the costs associated with the production of electricity, while the capacity component includes costs associated with the capability to deliver electric energy during peak periods. Capacity costs consist primarily of the costs associated with building peaking generation facilities. The forecasts of electric energy and capacity avoided costs and natural gas avoided costs used in this study were provided to GDS by the Michigan Public Service Commission. Avoided costs for natural gas include the avoided costs of the natural gas commodity and any other savings on the natural gas distribution system for operations and maintenance expenses or natural gas infrastructure expenditures.

At the consumer level, energy efficient products often cost more than their standard efficiency counterparts, but this additional cost is balanced by lower energy consumption and lower energy bills. Over time, the money saved from energy efficient products will pay consumers back for their initial investment as well as save them money on their electric and natural gas bills. Although some energy efficient technologies are complex and expensive, such as installing new high efficiency windows or a high efficiency boiler, many are simple and inexpensive. Installing compact fluorescent lighting or low-flow water devices, for example, can be done by most individuals.

Although the reduction in electric and natural gas costs is the primary benefit to be gained from investments in energy efficiency, the electric and natural gas utilities in Michigan, their consumers, and society as a whole can also benefit in other ways. Many electric efficiency measures also deliver non-energy benefits. For example, low-flow water devices and efficient clothes washers also reduce water consumption.[8] Similarly, weatherization measures that improve the building shell not only save on air conditioning costs in the summer, but also can save the customer money on space heating fuels, such as natural gas or propane. Reducing electricity consumption also reduces harmful emissions from power plants, such as SO_X, NO_X, CO_2 and particulates into the environment.[9]

Energy efficiency programs create both direct and indirect jobs. The manufacture and installation of energy efficiency products involves the manufacturing sector as well as research and development, service, and installation of jobs. These are skilled positions that are not easily outsourced to other states and countries. The creation of indirect jobs is more difficult to quantify, but result from households and businesses experiencing increased discretionary income from reduced energy bills. These savings produce multiplier effects, such as increased investment in other goods and services driving job creation in other markets.

Energy efficiency reduces risks associated with fuel price volatility, unanticipated capital cost increases, environmental regulations, supply shortages, and energy security. Aggressive energy efficiency programs can help eliminate or postpone the risk associated with committing to large investments for generation facilities a decade or more before they are needed. Energy efficiency is also not subject to the same supply and transportation constraints that impact fossil fuels. Finally, energy efficiency reduces competition between states and utilities for fuels, and reduces dependence on fuels imported from other states or countries to support electricity production. Energy efficiency can help meet future demand increases and reduce dependence on out-of-state or overseas resources.

3.2 THE MICHIGAN CONTEXT

3.2.1 Continuing Customer Growth

The annual kWh sales and electric system peak load for the State of Michigan is projected to increase over the next decade. From 2002 to 2011, the number of residential electric utility customers in Michigan remained fairly constant, growing at a rate of approximately 0.1% annually.[10] The electric load forecasts for Michigan developed by GDS indicates that the number of electric consumers in Michigan will continue to increase at a rate of 0.34% per year from 2014 through 2023 (the timeframe for this study) creating further growth in system electricity sales and peak demand. Natural gas sales, however, are projected to decrease slightly at a rate of -0.88% per year from 2014 to 2023. This report assesses the potential for electric and natural gas energy efficiency programs to assist the State of Michigan in meeting future electric and natural gas energy service needs.

3.2.2 Energy Efficiency Activity

Making homes and buildings more energy efficient is seen as a key strategy for addressing energy security, reducing reliance on fossil fuels from other countries, assisting consumers to lower energy bills, and addressing concerns about climate change. Faced with rapidly increasing energy prices, constraints in

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[8] The ENERGY STAR web site (www.energystar.gov) states that "ENERGY STAR qualified clothes washers use about 37% less energy and use over 50% less water than regular washers".

[9] The 2012 ENERGY STAR Annual Report states that 18,000 organizations across the US partnered with the US Environmental Protection Administration to improve energy efficiency while also realizing significant environmental and financial benefits. These EPA partners and individuals helped achieve energy savings while preventing more than 1.8 billion metric tons of GHG and saving over $230 billion on utility bills. Consumers and businesses that also partnered with ENERGY STAR also reduced their utility bills by $24 billion. With the help of ENERGY STAR, Americans were able to prevent 242 million metric tons of GHG during 2012, providing over $5.8 billion in benefits to society.

[10] This is the compound average annual growth rate for residential electric customers in Michigan.

energy supply and demand, and energy reliability concerns, states are turning to energy efficiency as the most reliable, cost-effective, and quickest resource to deploy.[11]

3.2.3 Recent Energy Efficiency Potential Studies

Table 3-1 below provides the results from a GDS review of recent energy efficiency potential studies conducted throughout the United States. It is useful to examine these results to understand if they are similar to this latest study for Michigan.

Table 3-1: Results of Recent Energy Efficiency Potential Studies in the US

STATE	STUDY YEAR	AUTHOR	STUDY PERIOD	# OF YEARS	ACHIEVABLE POTENTIAL
Missouri	2011	ACEEE (1)	2011-2020	10	6.4%
District of Columbia	2013	GDS (2)	2014-2023	10	29%
New Hampshire	2009	GDS (3)	2009-2018	10	20.5%
Rhode Island	2008	KEMA (4)	2009-2018	10	9.0%
Vermont	2011	GDS/Cadmus (5)	2012-2021	10	14.3%
New York City	2010	Global Energy Partners (6)	2011-2018	8	15%
USA	2009	McKinsey & Company (7)	2011-2020	10	23.0%
Pennsylvania	2012	Statewide Evaluator (8)	2013-2023	10	17.3%
Note 1: The ACEEE energy efficiency potential study builds on several energy efficiency potential studies conducted in Missouri from 2008 through 2011 and analyzes a specific suite of energy efficiency policies and programs.					
Note 2: The July 2013 District of Columbia potential study evaluated the maximum achievable potential scenario where incentives equaled 100% of measure incremental costs.					
Note 3: The 2009 New Hampshire potential study figure presented here is maximum achievable potential. Maximum Achievable potential is defined in this study as the maximum penetration of an efficient measure that would be adopted absent consideration of cost or customer behavior.					
Note 4: This 2010 KEMA report titled "Opportunity for Energy Efficiency That Is Cheaper Than Supply In Rhode Island" examined technical, economic and achievable potential for electric energy efficiency savings. Here is the definition of achievable potential used in that report: "Achievable program potential refers to the amount of cost-effective savings that are estimated to occur in response to a specific funded set of program activities. Achievable potential reflects *net* savings — in other words incremental savings over and above those projected to occur naturally from future changes in codes and standards or from other market activities outside of National Grid's efficiency program interventions and efforts. Achievable potential is estimated at the program level – namely groups of measures are bundled into program offerings					
Note 5: The 2011 Vermont study figure presented here is maximum achievable potential. Achievable potential in this study is defined as the amount of energy use that efficiency can realistically be expected to displace assuming the most aggressive program scenario possible (e.g., providing end-users with payments for the entire incremental cost of more efficiency equipment).					
Note 6: The 2010 New York City potential study figure provided here is maximum achievable potential.					
Note 7: The 2009 McKinsey & Company potential study only includes energy efficiency measures that can be hard-wired and excludes the impacts of all behavior-based programs.					
Note 8: The 2012 Pennsylvania potential study figure provided here is maximum achievable potential.					

A 2012 report by the American Council for an Energy Efficient Economy (ACEEE) offers information regarding the current savings and spending related to energy efficiency by state.[12] Based on self-reported

[11] The December 2008 National Action Plan for Energy Efficiency (NAPEE) "Vision for 2025: A Framework for Change" states that "the long-term aspirational goal for the Action Plan is to achieve all cost-effective energy efficiency by the year 2025. Based on studies, the efficiency resource available may be able to meet 50% or more of the expected load growth over this time frame, similar to meeting 20% of electricity consumption and 10 percent of natural gas consumption. The benefits from achieving this magnitude of energy efficiency nationally can be estimated to be more than $100 billion in lower energy bills in 2025 than would otherwise occur, over $500 billion in net savings, and substantial reductions in greenhouse gas emissions."

[12] American Council for an Energy Efficient Economy, "The 2010 State Energy Efficiency Scorecard", Report #E107, October 2010.

data, the eleven states annually spent more than 2% of electric sales revenue on electric energy efficiency programs in 2011. GDS has also examined actual energy efficiency savings data for 2010 and 2011 from the US Energy Information Administration (EIA) on the top twenty energy efficiency electric utilities. These top twenty utilities saved over 2% of annual kWh sales in 2010 with their energy efficiency programs, and 3.8% of annual kWh sales in 2011. These percentage savings are attributable to energy efficiency measures installed in a one-year time frame and demonstrate what can be accomplished with full-scale and aggressive implementation of programs.

3.3 COST-EFFECTIVENESS FINDINGS

The Total Resource Cost Test and Utility Cost Test calculations in this study follow the prescribed methodology detailed in the latest version of the California Standard Practice Manual (CA SPM). The California Standard Practice Manual establishes standard procedures for cost-effectiveness evaluations for utility-sponsored or public benefits programs and is generally considered to be an authoritative source for defining cost-effectiveness criteria and methodology. This manual is often referenced by many other states and utilities.

The GDS cost effectiveness screening tool used for this study quantifies all of the benefits and costs included in these two tests (TRC and UCT tests). For purposes of this study, quantified benefits of the TRC Test include electric energy and capacity avoided supply costs, avoided electric transmission and distribution avoided costs, and alternative fuel and water savings. GDS has also included a risk adjusted value for reduced carbon emissions valued at $9.25 per ton of carbon emissions avoided.[13] Costs include the specified measure cost (incremental or full cost, as applicable), any increase in supply costs (electric or fossil fuel), as well as operation and maintenance costs. In addition, the GDS screening tool is capable of evaluation of cost-effectiveness based on various market replacement approaches, including replace-on-burnout, retrofit, and early retirement.

The forecast of electric and natural gas avoided costs of energy and generation capacity were obtained from the Michigan PSC. The value for electric T&D avoided costs were obtained from a report from the New York Public Service Commission based on the upstate New York region.

This energy efficiency potential study concludes that there remains significant achievable cost effective potential for electric and natural gas energy efficiency measures and programs in Michigan. Tables 3-2, 3-3 and 3-4 show benefit-cost ratios for the three scenarios examined in this study for the five and ten-year implementation periods starting in 2014.

Table 3-2: Scenario #1: Utility Cost Test Benefit-Cost Ratios for the Achievable Potential Scenario Based on UCT Screening (50% Incentives) For 5-Year and 10-Year Implementation Periods

ACHIEVABLE POTENTIAL SCENARIOS	UCT $ BENEFITS	UCT $ COSTS	UCT BENEFIT/COST RATIO
5-yr period	$8,819,456,909	$3,452,121,731	2.55
10-yr period	$15,854,685,097	$5,807,771,171	2.73

[13] This value represents the expected value for reduced carbon emissions based on an equal weighting of a scenario with no carbon taxes and a scenario where carbon is valued at $18.50 per ton of reduced emissions. The $18.50 per ton figure was obtained from a recent filing by Commonwealth Edison in Illinois.

Table 3-3: Scenario #2: TRC Test Benefit-Cost Ratios for the Achievable Potential Scenario Based on TRC Screening For 5-Year and 10-Year Implementation Periods

ACHIEVABLE POTENTIAL SCENARIOS	TRC $ BENEFITS	TRC $ COSTS	TRC BENEFIT/COST RATIO
5-yr period	$9,090,916,601	$3,542,860,326	2.57
10-yr period	$16,434,033,885	$6,063,428,268	2.71

Table 3-4: Scenario #3: Benefit-Cost Ratios for the Constrained Achievable Potential Scenario Based on the UCT Test for 5-Year and 10-Year Implementation Periods

ACHIEVABLE POTENTIAL SCENARIOS	UCT $ BENEFITS	UCT $ COSTS	UCT BENEFIT/COST RATIO
5-yr period	$3,134,114,985	$1,212,231,599	2.59
10-yr period	$5,996,092,253	$2,145,524,086	2.79

4 CHARACTERIZATION OF ELECTRICITY AND NATURAL GAS CONSUMPTION IN MICHIGAN

This chapter provides up-to-date historical and forecast information on electricity and natural gas consumption, consumption by market segment and by energy end use, and electric and natural gas customers in the State of Michigan. This chapter also provides an overview of the number of households and housing units in Michigan. Developing this information is a fundamental part of any energy efficiency potential study. It is necessary to understand how energy is consumed in a state or region before one can assess the energy efficiency savings potential that remains to be tapped.

4.1 MICHIGAN ELECTRIC AND NATURAL GAS UTILITIES

There are multiple utilities that provide electric and natural gas to Michigan customers. According to data from the Michigan Public Service Commission, Michigan has 8 investor-owned electric utilities, 41 municipal electric utilities, and 10 electric distribution cooperatives. There are 6 utilities in Michigan that provide piped natural gas to consumers. The two largest electric utilities are DTE Energy Company (DTE) and Consumers Energy. These two utilities provide approximately 92% of electric energy sales in the State.

Figure 4-1 shows the service areas for electric distribution utilities in Michigan, with the largest two companies, DTE and Consumers Energy taking up much of the geographic region of the state. Note that the size of utility service areas varies greatly. Figure 4-2 displays the service areas of the utilities that distribute piped natural gas throughout the state.

Figure 4-1: Michigan Electric Utility Service Territories

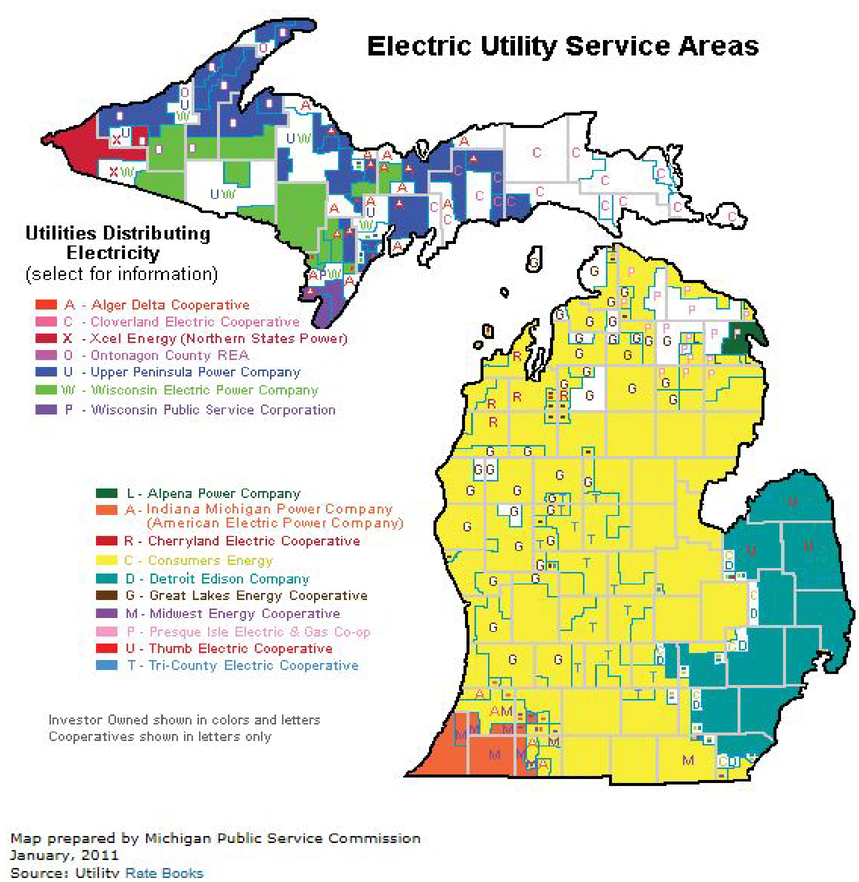
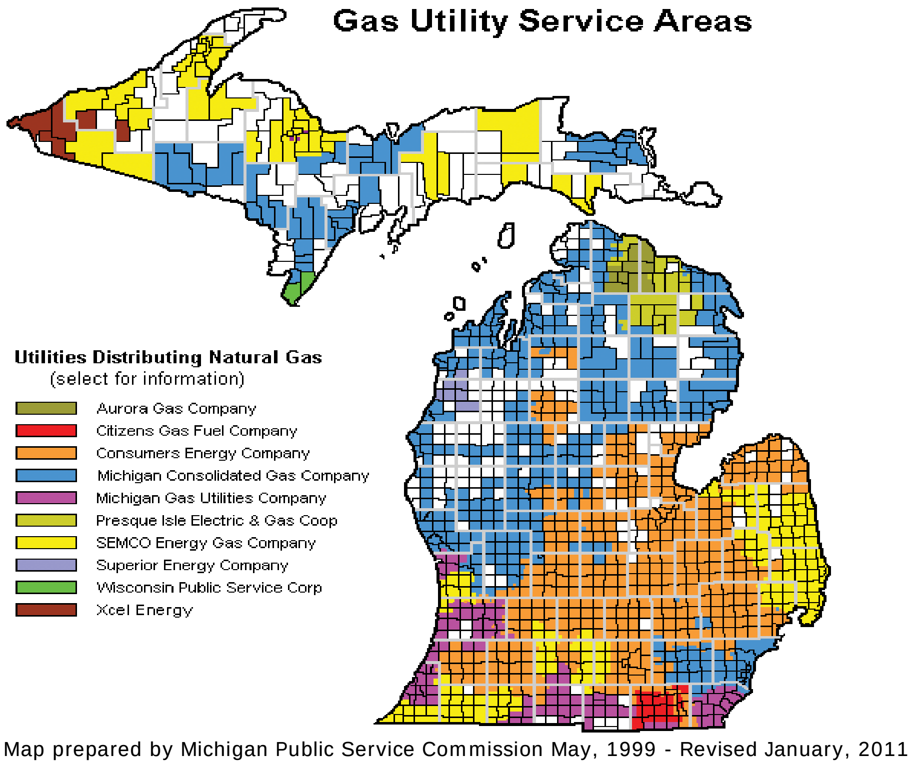


Figure 4-2: Michigan Natural Gas Utility Service Territories



4.1.1 Detroit Edison Energy Company (DTE)

The DTE Energy provides electricity mainly in southeastern Michigan and provides natural gas services throughout the state of Michigan. DTE supplies electricity and natural gas to 2.1 million and 1.2 million customers respectively throughout the entire state.

4.1.2 Consumers Energy

Consumers Energy is one of the largest combined utilities (electric and natural gas) in the country, providing services to a population of 6.8 million of the 10 million citizens in the states.

4.2 ECONOMIC/DEMOGRAPHIC CHARACTERISTIC

Michigan is located in the Great Lakes and the Midwestern region of the United States. It is the 11th largest state. It borders Wisconsin, Ohio, Indiana, Minnesota, and Canada. Michigan is 96,810 square miles, bordering four of the Great Lakes: Lake Michigan, Lake Superior, Lake Huron, and Lake Erie. Michigan's population is 9,883,635 residents[14], ranking Michigan as the 8th most populated state in the country.

According to an estimate done by the Census Bureau, during the year 2012, there were about 175 people per square mile in the state of Michigan. The state's population distribution by age is as follows:

- Under 5 – 7.6%
- Ages 5-19 – 22.6%
- Ages 19-65 - 46.8%
- Above 65 – 23%

[14] U.S. Department of Commerce, Bureau of the Census, at www.census .gov on October 7, 2013.

The estimated number of Michigan housing units from the 2010 census was 4,532,233. Table 4-1 and Table 4-2 provides historical and forecast data for the number of electric and natural gas customers by sector in Michigan.

Table 4-1: Number of Electric Customers by Market Sector

YEAR	RESIDENTIAL ELECTRIC CUSTOMERS	COMMERCIAL ELECTRIC CUSTOMERS	INDUSTRIAL ELECTRIC CUSTOMERS	TOTAL ELECTRIC CUSTOMERS
2003	4,216,573	483,168	14,224	**4,713,965**
2004	4,248,920	504,754	14,322	**4,767,996**
2005	4,284,083	509,964	13,390	**4,807,437**
2006	4,299,273	514,049	13,317	**4,826,639**
2007	4,298,455	518,058	13,227	**4,829,740**
2008	4,290,313	518,776	12,776	**4,821,865**
2009	4,253,786	520,551	13,065	**4,787,402**
2010	4,245,158	520,233	12,827	**4,778,218**
2011	4,249,136	521,322	12,961	**4,783,419**
2012	4,249,100	520,674	12,829	**4,782,603**
2013	4,251,335	522,599	13,070	**4,787,004**
2014	4,258,028	524,034	13,108	**4,795,170**
2015	4,266,512	525,411	13,127	**4,805,050**
2016	4,277,366	526,820	13,139	**4,817,325**
2017	4,289,689	528,188	13,146	**4,831,023**
2018	4,305,113	529,714	13,153	**4,847,980**
2019	4,321,703	531,212	13,160	**4,866,075**
2020	4,338,945	532,660	13,166	**4,884,771**
2021	4,356,733	534,067	13,171	**4,903,971**
2022	4,375,466	535,463	13,177	**4,924,106**
2023	4,395,035	536,848	13,183	**4,945,066**
2024	4,415,254	535,425	13,189	**4,963,868**

Table 4-2: Number of Natural Gas Customers by Market Sector

YEAR	RESIDENTIAL NATURAL GAS CUSTOMERS	COMMERCIAL NATURAL GAS CUSTOMERS	INDUSTRIAL NATURAL GAS CUSTOMERS	TOTAL NATURAL GAS CUSTOMERS
2002	3,110,743	247,818	10,468	**3,369,029**
2003	3,140,021	246,123	10,378	**3,396,522**
2004	3,161,370	246,991	10,088	**3,418,449**
2005	3,187,583	253,415	10,049	**3,451,047**
2006	3,193,920	254,923	9,885	**3,458,728**
2007	3,188,152	253,139	9,728	**3,451,019**
2008	3,172,623	252,382	10,563	**3,435,568**
2009	3,169,026	252,017	18,186	**3,439,229**

YEAR	RESIDENTIAL NATURAL GAS CUSTOMERS	COMMERCIAL NATURAL GAS CUSTOMERS	INDUSTRIAL NATURAL GAS CUSTOMERS	TOTAL NATURAL GAS CUSTOMERS
2010	3,152,468	249,309	9,332	**3,411,109**
2011	3,153,895	249,456	9,088	**3,412,439**
2012	3,163,925	249,850	8,833	**3,422,609**
2013	3,173,955	250,245	8,579	**3,432,779**
2014	3,183,986	250,639	8,324	**3,442,949**
2015	3,197,789	251,082	8,287	**3,457,158**
2016	3,213,198	251,775	8,250	**3,473,222**
2017	3,228,297	251,653	8,212	**3,488,162**
2018	3,243,686	253,195	8,175	**3,505,055**
2019	3,258,606	253,389	8,152	**3,520,147**
2020	3,273,842	253,972	8,120	**3,535,934**
2021	3,289,150	254,559	8,087	**3,551,796**
2022	3,304,524	255,350	8,064	**3,567,938**
2023	3,319,876	255,751	8,035	**3,583,663**
2024	3,335,417	256,451	8,005	**3,599,873**

4.3 COMMERCIAL AND INDUSTRIAL SECTOR BASELINE SEGMENTATION FINDINGS

This section provides detailed information on the breakdown of commercial and industrial electricity and natural gas sales in Michigan by market segment and end use.

4.3.1 Electricity Sales by Sector, by EDC

Figure 4-3 and Table 4-3 show historical and forecast electricity sales by sector (in millions of kWh) for the State of Michigan for the period 2002 to 2024. Both DTE Energy and Consumers Energy do not have electric sales and peak load forecasts that exclude all impacts of their current energy efficiency programs. As a result, the forecast of annual electric sales for Michigan shown below do reflect the impacts of current energy efficiency programs.

Figure 4-3: Michigan Annual Electric Sales

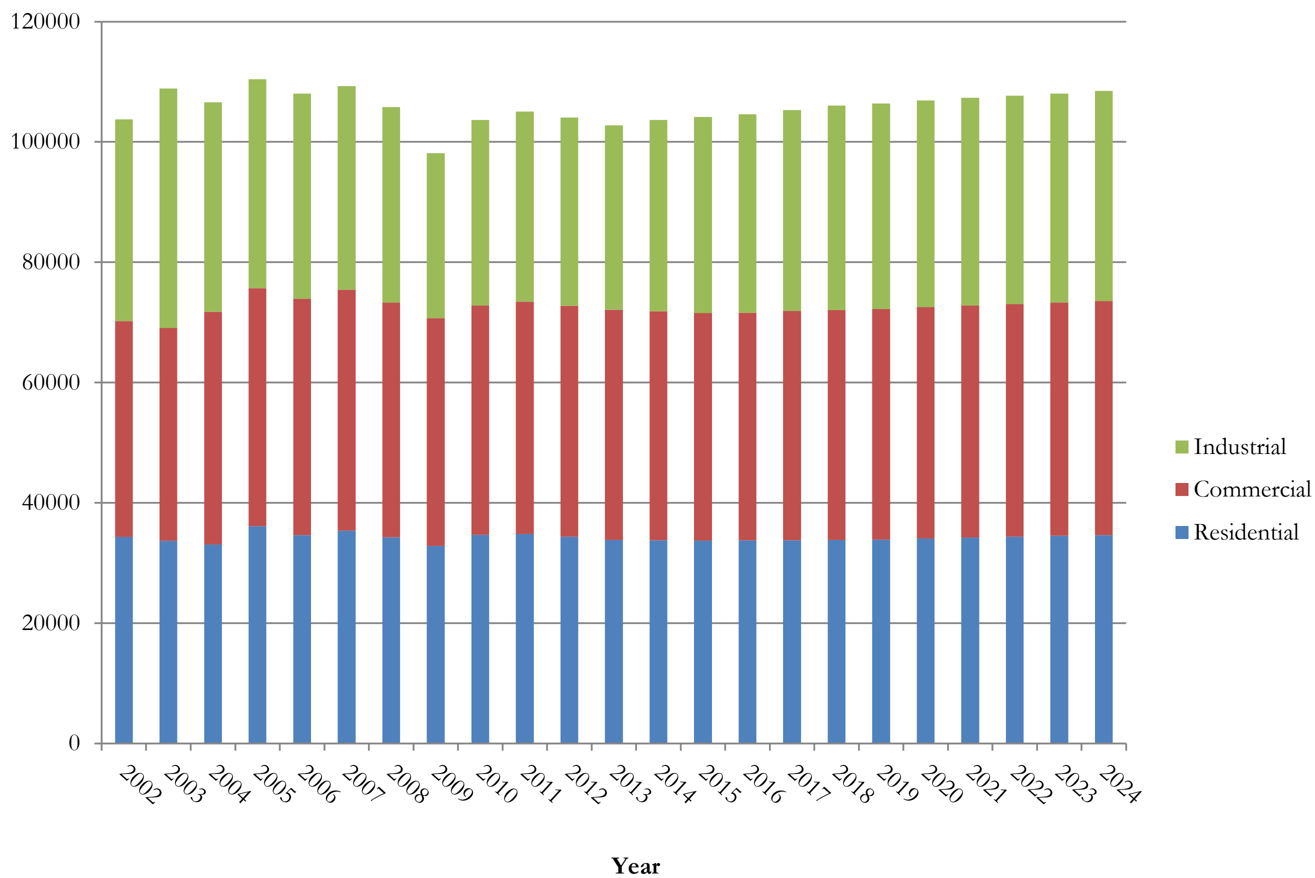


Table 4-3: Michigan Actual and Projected Electric GWh Sales by Sector

YEAR	RESIDENTIAL	COMMERCIAL	INDUSTRIAL	TOTAL
2002	34,336	35,880	33,537	**103,753**
2003	33,669	35,391	39,813	**108,873**
2004	33,104	38,632	34,867	**106,603**
2005	36,095	39,600	34,745	**110,440**
2006	34,622	39,299	34,093	**108,014**
2007	35,366	40,047	33,879	**109,292**
2008	34,297	38,974	32,505	**105,776**
2009	32,854	37,870	27,391	**98,115**
2010	34,681	38,123	30,841	**103,645**
2011	34,811	38,613	31,624	**105,048**
2012	34,400	38,367	31,305	**104,072**
2013	33,812	38,289	30,669	**102,770**
2014	33,775	38,075	31,795	**103,645**
2015	33,726	37,822	32,582	**104,130**
2016	33,797	37,807	32,987	**104,591**
2017	33,780	38,114	33,380	**105,274**

YEAR	RESIDENTIAL	COMMERCIAL	INDUSTRIAL	TOTAL
2018	33,804	38,236	34,022	**106,062**
2019	33,903	38,349	34,149	**106,401**
2020	34,073	38,458	34,370	**106,901**
2021	34,239	38,561	34,548	**107,348**
2022	34,390	38,660	34,637	**107,687**
2023	34,503	38,789	34,746	**108,038**
2024	34,612	38,947	34,928	**108,487**

4.3.2 Natural Gas Sales by Sector, by EDC

Figure 4-4 presents historical and forecast natural gas sales by sector for the State of Michigan (in MMbtu) for the period 2002 to 2022. The commercial sector is the largest sector of natural gas sales, followed by residential and industrial. Table 4-4 presents historical and forecast data in numerical format for natural gas sales in Michigan by sector for the period 2002 to 2024. Both DTE Energy and Consumers Energy do not have natural gas sales forecasts that exclude all impacts of their current energy efficiency programs. As a result, the forecast of annual natural gas sales for Michigan shown below do reflect the impacts of current energy efficiency programs. GDS also points out that the forecast of natural gas sales for Michigan does not include natural gas used for electric generation.

Figure 4-4: Michigan Natural Gas Sales Forecast (MMBtu)

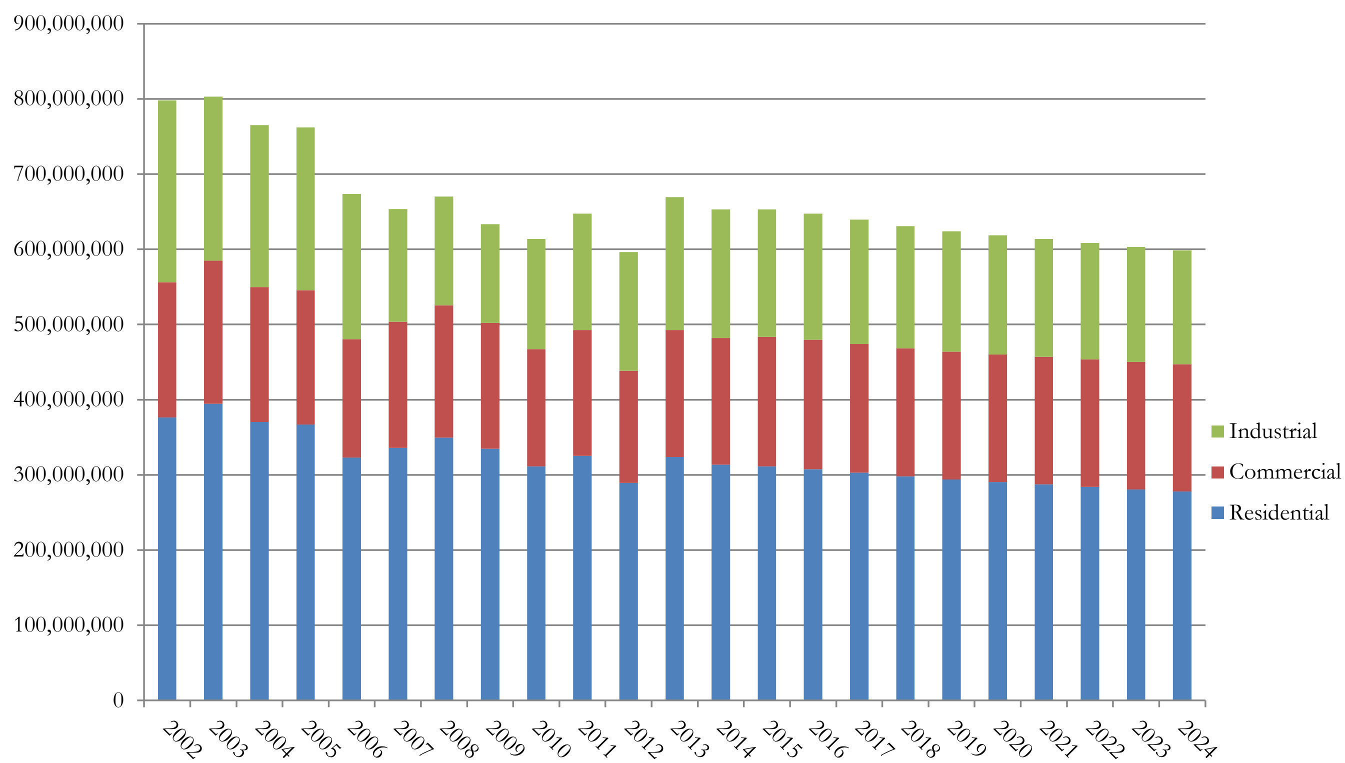


Table 4-4: Michigan Actual and Projected Natural Gas Sales by Sector (MMBtu)

YEAR	RESIDENTIAL	COMMERCIAL	INDUSTRIAL	TOTAL
2002	376,223,595	180,058,230	241,564,059	**797,845,884**
2003	394,436,064	190,409,967	218,156,796	**803,002,827**
2004	370,350,552	179,219,370	215,342,523	**764,912,445**
2005	366,871,329	178,641,375	216,404,397	**761,917,101**
2006	323,031,687	157,435,608	192,843,684	**673,310,979**
2007	335,985,936	167,506,020	149,956,455	**653,448,411**
2008	349,614,342	176,066,484	144,429,186	**670,110,012**
2009	334,636,599	167,447,709	131,459,592	**633,543,900**
2010	311,329,590	155,854,050	146,648,073	**613,831,713**
2011	325,318,092	167,329,041	154,557,909	**647,205,042**
2012	289,473,172	149,024,502	157,851,969	**596,349,643**
2013	323,647,940	169,062,257	176,487,735	**669,197,931**
2014	313,567,812	168,397,349	170,990,963	**652,956,125**
2015	311,401,049	171,899,663	169,809,411	**653,110,123**
2016	307,589,232	172,012,348	167,730,797	**647,332,377**
2017	302,872,404	171,290,048	165,158,674	**639,321,127**
2018	297,889,970	170,273,089	162,441,714	**630,604,773**
2019	293,841,544	169,924,537	160,234,076	**624,000,158**
2020	290,497,097	169,632,911	158,410,323	**618,540,331**
2021	287,348,809	169,585,551	156,693,537	**613,627,897**
2022	284,092,085	169,475,200	154,917,620	**608,484,904**
2023	280,795,642	169,324,020	153,120,044	**603,239,706**
2024	277,777,232	169,401,943	151,474,082	**598,653,258**

4.3.3 Electricity Consumption by Market Segment

Figure 4-5 shows the breakdown of electricity consumption by building type for the commercial sector. Figure 4-6 shows a similar breakdown of sales by industrial market segment for the industrial sector. The Office market sector (29%) consumes the largest share of commercial electricity consumption, followed by Other (21%) and Retail (11%). In the industrial sector, Transportation Equipment (25% of annual industrial electricity sales) is the largest sector, followed by Primary Metals (20%) and Chemistry (10%).

Figure 4-5: 2014 Commercial Electricity Consumption by Market Segment

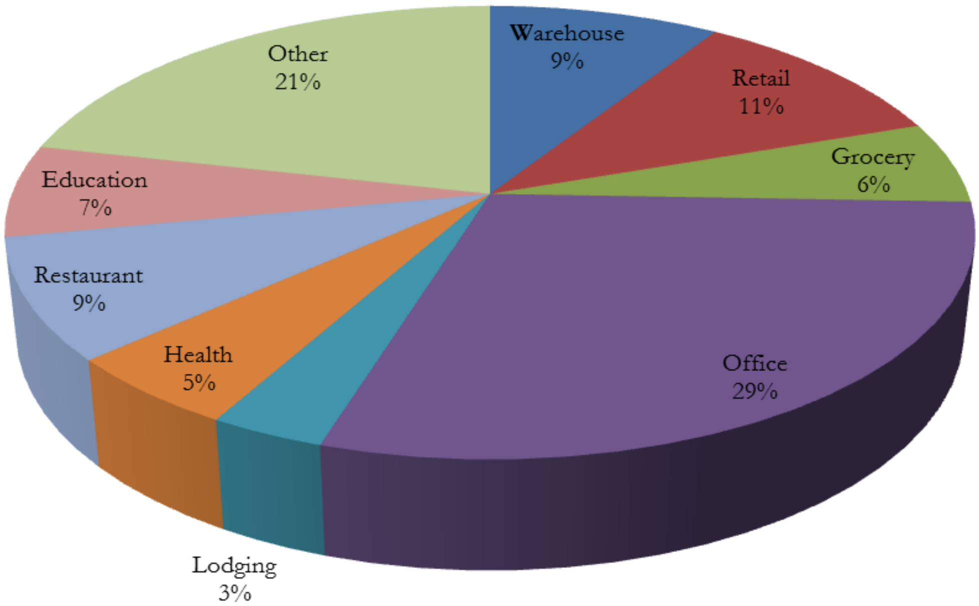


Figure 4-6: 2014 Electric Industrial Energy Consumption by Market Segment

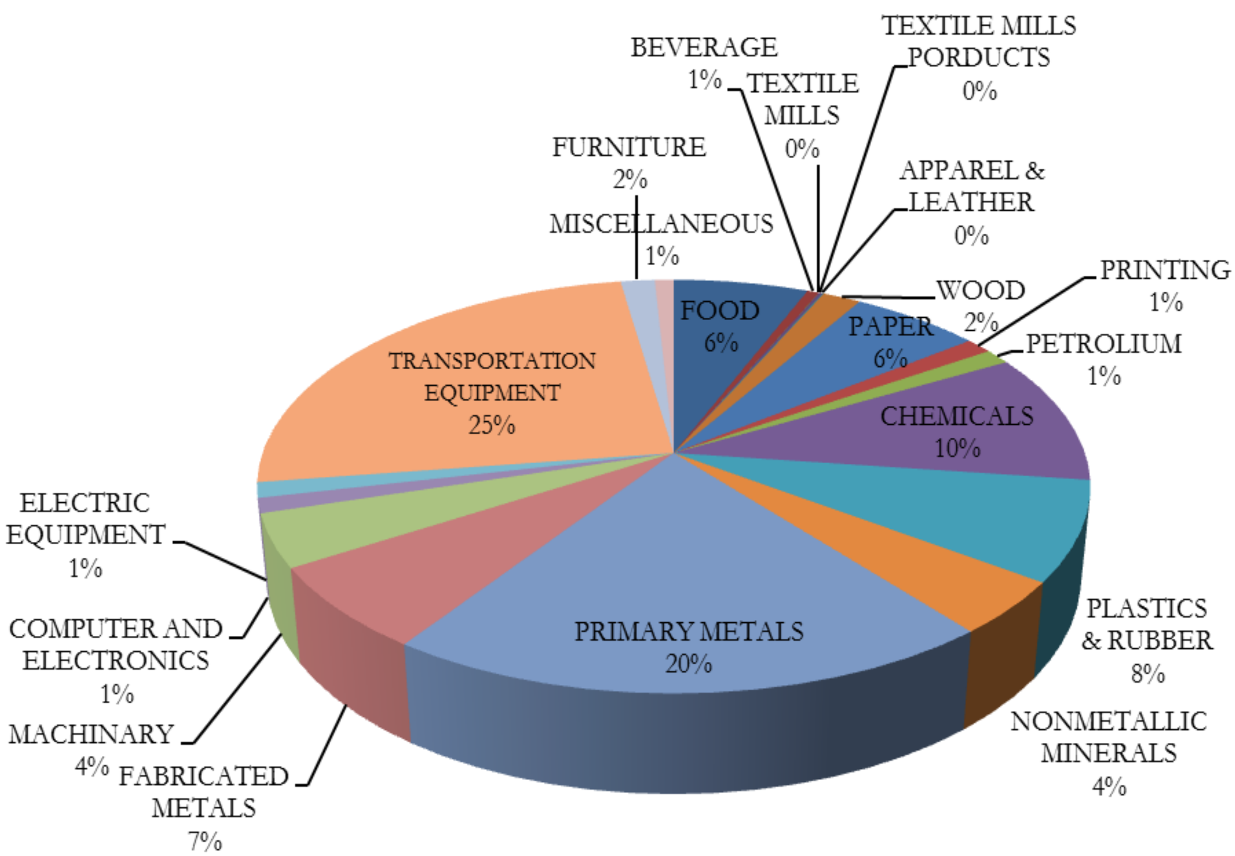


Table 4-5: 2014 Electric Industrial Energy Consumption by Segment

SEGMENT	CONSUMPTION (MWH)	ELECTRICITY SHARE
Food	1,944,291	6%
Beverage	171,696	1%
Textile Mills	3,070	0%
Textile Mill Products	51,185	0%
Apparel & Leather	19,863	0%
Wood	551,294	2%
Paper	1,871,906	6%
Printing	383,711	1%
Petroleum	378,873	1%
Chemicals	3,238,019	10%
Plastics & Rubber	2,481,706	8%
Nonmetallic Minerals	1,342,118	4%
Primary Metals	6,515,086	20%
Fabricated Metals	2,102,667	7%
Machinery	1,321,084	4%
Computer & Electronics	368,783	1%
Electric Equipment	380,700	1%
Transportation Equipment	7,904,144	25%
Furniture	492,726	2%
Miscellaneous	271,813	1%
Total	**31,794,736**	**100%**

4.3.4 Electric Consumption by End-Use

Table 4-6 shows the breakdown of electric energy consumption by commercial market segment by end use. Tables 4-7, 4-8, and 4-9 show the same breakdown for the industrial sector by market segment. Lighting is the largest end use for the commercial sector (37% of commercial sector electricity consumption), followed by cooling (14%), and then by ventilation (13%). As for the industrial sector, machine drives represent the largest end use, followed by process heating and facility HVAC.

Table 4-6: Breakdown of Michigan Commercial Electricity Sales by Market Segment and End-Use

	WAREHOUSE	RETAIL	GROCERY	OFFICE	LODGING	HEALTH	RESTAURANT	EDUCATION	OTHER	TOTAL
Lighting	54%	42%	22%	39%	54%	42%	19%	31%	32%	**37%**
Cooling	6%	15%	6%	14%	10%	14%	13%	21%	17%	**14%**
Ventilation	8%	9%	3%	9%	6%	16%	11%	22%	24%	**13%**
Water Heating	1%	5%	1%	1%	4%	1%	5%	3%	1%	**2%**
Refrigeration	14%	7%	55%	5%	4%	3%	32%	5%	9%	**12%**
Space Heating	1%	8%	3%	5%	6%	3%	5%	4%	4%	**4%**
Office Equipment	3%	2%	3%	15%	3%	5%	2%	9%	2%	**7%**
Miscellaneous	13%	12%	6%	13%	12%	15%	13%	6%	11%	**12%**
Total	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**

Table 4-7: Electric Industrial Energy Consumption by End Use (Table 1 of 3)

	FOOD	BEVERAGE	TEXTILE MILLS	TEXTILE MILL PRODUCTS	APPAREL & LEATHER	WOOD	PAPER
Conventional Boiler Use	3%	2%	1%	1%	1%	1%	2%
Process Heating	5%	6%	7%	9%	6%	6%	3%
Process Cooling and Refrigeration	28%	26%	9%	6%	4%	1%	1%
Machine Drive	43%	34%	54%	47%	36%	72%	75%
Electro-Chemical Processes	0%	0%	1%	1%	1%	1%	1%
Other Process Use	1%	2%	3%	1%	2%	1%	4%
Facility HVAC (g)	8%	10%	12%	16%	26%	6%	4%
Facility Lighting	8%	8%	8%	15%	16%	8%	4%
Other Facility Support	2%	2%	2%	3%	4%	2%	1%
Onsite Transportation	0%	0%	0%	0%	0%	0%	0%
Other Non-process Use	0%	0%	0%	0%	0%	1%	0%
End Use Not Reported	2%	9%	3%	1%	4%	2%	4%
Total Industrial	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**

Table 4-8: Electric Industrial Energy Consumption by End Use (Table 2 of 3)

	PRINTING	PETROLEUM	CHEMICALS	PLASTICS & RUBBERS	NONMETALLIC MINERAL	PRIMARY METALS
Conventional Boiler Use	1%	1%	1%	1%	0%	0%
Process Heating	4%	0%	4%	18%	26%	32%
Process Cooling and Refrigeration	5%	5%	8%	11%	3%	1%
Machine Drive	46%	83%	59%	43%	54%	28%
Electro-Chemical Processes	1%	0%	15%	0%	1%	26%
Other Process Use	1%	2%	1%	3%	2%	3%
Facility HVAC (g)	24%	4%	6%	10%	6%	4%
Facility Lighting	9%	3%	4%	8%	5%	3%
Other Facility Support	3%	1%	1%	2%	1%	1%
Onsite Transportation	0%	0%	0%	0%	0%	0%
Other Non-process Use	1%	0%	0%	0%	0%	0%
End Use Not Reported	4%	2%	1%	2%	1%	0%
Total Industrial	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**

Table 4-9: Electric Industrial Energy Consumption by End Use (Table 3 of 3)

	FABRICATED METALS	MACHINERY	COMPUTERS & ELECTRONICS	ELEC. EQUIP.	TRANS EQUIP.	FURNITURE	MISC.	TOTAL INDUSTRIAL
Conventional Boiler Use	0%	1%	1%	1%	1%	1%	1%	**277,716**
Process Heating	21%	11%	10%	15%	11%	5%	11%	**4,816,452**
Process Cooling and Refrigeration	3%	3%	9%	4%	5%	1%	5%	**1,868,622**
Machine Drive	41%	40%	23%	37%	36%	47%	30%	**13,500,396**
Electro-Chemical Processes	3%	0%	2%	5%	2%	1%	5%	**2,521,134**
Other Process Use	3%	3%	5%	4%	4%	2%	3%	**889,721**
Facility HVAC (g)	9%	20%	30%	15%	19%	18%	25%	**3,445,271**
Facility Lighting	11%	15%	12%	10%	15%	17%	14%	**2,754,603**
Other Facility Support	2%	4%	5%	7%	3%	4%	4%	**716,870**
Onsite Transportation	0%	0%	0%	0%	1%	1%	0%	**93,715**
Other Non-process Use	0%	1%	1%	0%	1%	1%	0%	**175,298**
End Use Not Reported	6%	1%	4%	0%	3%	4%	1%	**734,938**
Total Industrial	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**31,794,736**

4.3.5 Natural Gas Consumption by Market Segment

Figure 4-7 shows the breakdown of Michigan natural gas sales by commercial market segment. Figure 4-8 and Table 4-10 show a similar breakdown for the industrial market segment. The Other segment (23%) consumes the largest share of the commercial sector natural gas consumption, followed by the Office (21%) and Education (15%) market segments. In the industrial sector, the Chemicals (21%) market segment consumes the largest amount of natural gas, followed by Transportation Equipment (19%) and Primary Metals (13%). 2010 EIA MECS End Use Data was used to obtain end use percentage breakdowns of electricity and natural gas use for each major industrial NAICS category at the national level. 2011 Census data for each major industrial NAICS category was used to obtain electricity use and fuel consumption as well as value of product shipments for each category. This was used to generate MWh of electricity per dollar of product shipped and MMBtu of natural gas per dollar of product shipped for each NAICS category, and these ratios were multiplied by the Michigan-specific values of product shipped per NAICS category to obtain estimated 2011 MWh of electricity consumption and MMBtu of natural gas consumption per NAICS category in Michigan and percent of total industrial electricity and natural gas consumption represented by each NAICS category. These NAICS category percentages were then multiplied by forecasted Michigan Industrial electricity and gas consumption for 2014 and 2023 to assign the forecasted consumption to each NAICS category. The end use percentage breakdowns were then applied to forecast total consumption for each SIC category to obtain estimated electricity and natural gas consumption for each end use in each Industrial NAICS category for 2014 and 2023.

Figure 4-7: Natural Gas Commercial Energy Consumption by Market Segment

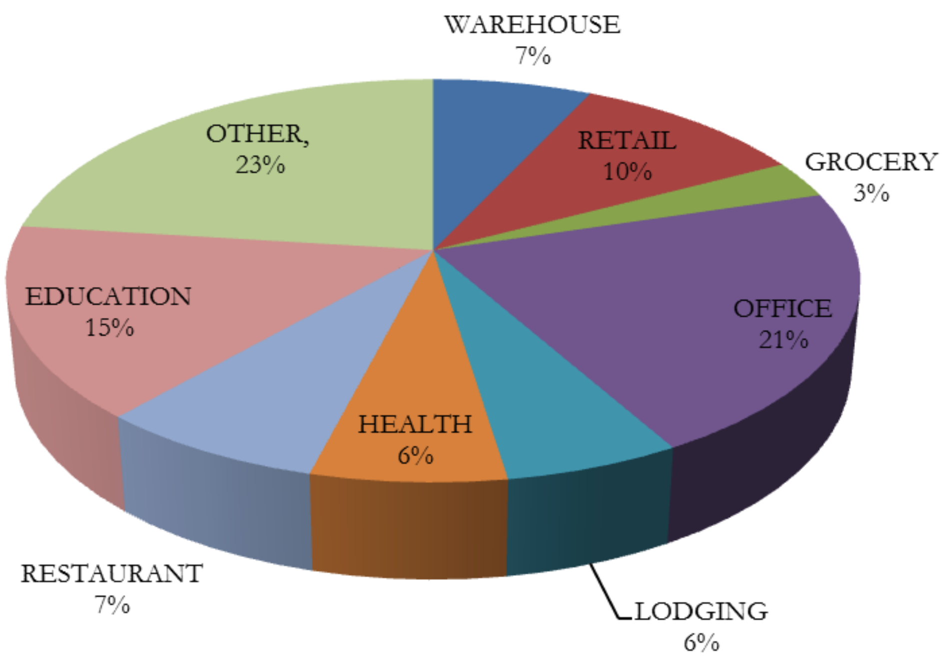


Figure 4-8: Natural Gas Industrial Energy Consumption by Market Segment

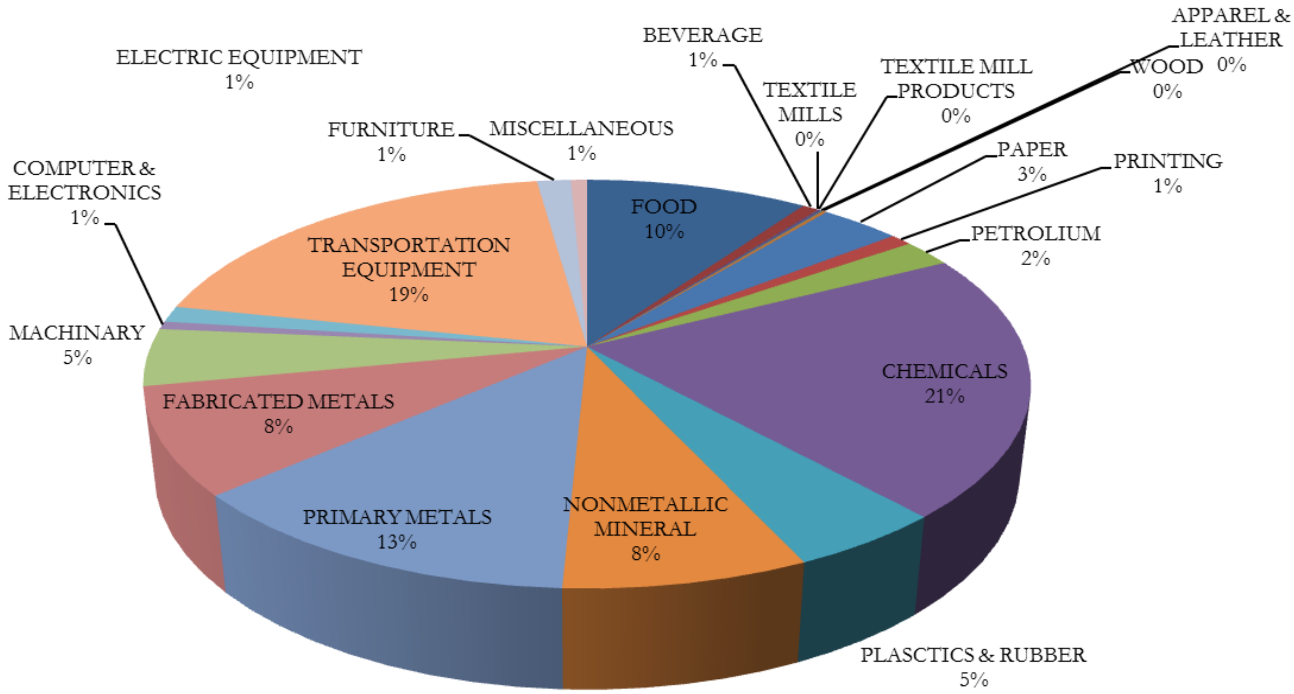


Table 4-10: Natural Gas Industrial Energy Consumption by Market Segment

SEGMENT	CONSUMPTION (MWH)	ELECTRICITY SHARE
Food	16,642,808	10%
Beverage	1,224,421	1%
Textile Mills	13,049	0%
Textile Mill Products	274,779	0%
Apparel & Leather	104,123	0%
Wood	331,865	0%
Paper	5,978,556	3%
Printing	1,635,620	1%
Petroleum	3,749,816	2%
Chemicals	36,124,119	21%
Plastics & Rubber	8,302,233	5%
Nonmetallic Minerals	12,978,192	8%
Primary Metals	21,883,749	13%
Fabricated Metals	14,532,992	8%
Machinery	7,828,921	5%
Computer & Electronics	1,082,742	1%
Electric Equipment	2,198,993	1%
Transportation Equipment	33,526,892	19%
Furniture	2,534,560	1%
Miscellaneous	1,212,561	1%

SEGMENT	CONSUMPTION (MWH)	ELECTRICITY SHARE
Total	**172,160,990**	**100%**

4.3.6 Natural Gas Consumption by End-Use

Table 4-11 shows the breakdown of natural gas consumption by commercial market segment by end use. Tables 4-12, 4-13, and 4-14 show the same breakdown for the industrial sector. The largest natural gas end use in the commercial sector is space heating, followed by water heating and cooking. In the industrial sector, the largest end use is process heating.

Table 4-11: Natural Gas Commercial Energy Consumption by End-Use

	WAREHOUSE	RETAIL	GROCERY	OFFICE	LODGING	HEALTH	RESTAURANT	EDUCATION	OTHER
Space Heating	84%	71%	69%	86%	30%	56%	27%	77%	85%
Water Heating	3%	7%	5%	5%	58%	30%	23%	14%	4%
Cooking	0%	9%	21%	1%	7%	4%	45%	2%	8%
Other	13%	13%	5%	9%	6%	9%	6%	7%	0%
Total	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**98%**

Table 4-12: Natural Gas Industrial Energy Consumption by End-Use (Table 1 of 3)

	FOOD	BEVERAGE	TEXTILE MILLS	TEXTILE MILL PRODUCTS	APPAREL & LEATHER	WOOD	PAPER
Conventional Boiler Use	28%	24%	26%	25%	25%	6%	13%
Process Heating	30%	24%	35%	38%	25%	62%	30%
CHP and/or Cogeneration Process	29%	41%	29%	25%	25%	18%	48%
Facility HVAC (g)	6%	11%	6%	13%	25%	12%	4%
Process Cooling and Refrigeration	0%	0%	0%	0%	0%	0%	0%
Machine Drive	1%	0%	0%	0%	0%	3%	3%
Other Process Use	1%	0%	0%	0%	0%	0%	1%
End Use Not Reported	1%	0%	3%	0%	0%	0%	2%
Other Facility Support	3%	0%	0%	0%	0%	0%	0%
Other Non-process Use	0%	0%	0%	0%	0%	0%	0%
Total Industrial	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**

Table 4-13: Natural Gas Industrial Energy Consumption by End-Use (Table 2 of 3)

	Printing	Petroleum	Chemicals	Plastics & Rubbers	Nonmetallic Minerals	Primary Metals
Conventional Boiler Use	10%	12%	17%	19%	1%	4%
Process Heating	45%	56%	35%	35%	87%	75%
CHP and/or Cogeneration Process	13%	22%	39%	24%	3%	8%
Facility HVAC (g)	29%	0%	1%	22%	6%	7%
Process Cooling and Refrigeration	0%	1%	0%	0%	0%	1%
Machine Drive	3%	2%	4%	0%	1%	2%
Other Process Use	0%	3%	3%	0%	0%	3%
End Use Not Reported	0%	4%	0%	0%	2%	0%
Other Facility Support	0%	0%	0%	1%	0%	1%
Other Non-process Use	0%	0%	0%	0%	0%	0%
Total Industrial	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**

Table 4-14: Natural Gas Industrial Energy Consumption by End-Use (Table 3 of 3)

	Fabricated Metals	Machinery	Computers & Electronics	Elec. Equip.	Trans Equip.	Furniture	Misc.	Total Industrial
Conventional Boiler Use	8%	4%	27%	11%	11%	0%	13%	**20,759,627**
Process Heating	63%	41%	12%	54%	35%	46%	27%	**79,914,353**
CHP and/or Cogeneration Process	7%	4%	7%	9%	14%	8%	20%	**33,762,602**
Facility HVAC (g)	20%	48%	44%	20%	33%	46%	40%	**26,638,960**
Process Cooling and Refrigeration	0%	0%	0%	0%	0%	0%	0%	**362,627**
Machine Drive	1%	1%	0%	0%	0%	0%	0%	**2,515,680**
Other Process Use	1%	0%	2%	0%	6%	0%	0%	**4,008,079**
End Use Not Reported	0%	0%	5%	3%	1%	0%	0%	**1,165,518**
Other Facility Support	1%	1%	2%	3%	2%	0%	0%	**1,754,341**
Other Non-process Use	0%	0%	0%	0%	0%	0%	0%	**109,175**
Total Industrial	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**170,990,963**

4.4 CURRENT MICHIGAN EDC ENERGY EFFICIENCY PROGRAMS

4.4.1 Current DTE Energy Efficiency Programs

DTE Energy provides several energy efficiency programs to Michigan electric and natural gas customers in the residential, commercial and industrial markets.

4.4.1.1 Residential Programs

Residential Energy Efficiency Program (Electric)

DTE offers energy audit discounts and rebates for the installation of energy efficiency improvements. Eligible measures and equipment includes: programmable thermostats, energy audits, insulation, central ac systems, appliance recycling, and air sealing.

Residential Energy Efficiency Program (Gas)

Rebate levels vary according to whether the customer receives MichCon gas, DTE electric service, or both. Eligible measures and equipment include the following high efficiency appliances: clothes washers, dehumidifiers, programmable thermostats, energy audits, insulation, high efficiency room air conditioners, appliance recycling, furnaces, boilers, air sealing, and energy audit. Rebate amounts can also vary based on equipment size and efficiency level. Participation is first come-first serve, and an energy audit should be completed prior to equipment installations.

4.4.1.2 Commercial/ Industrial Programs

Commercial and Industrial Energy Efficiency Program (Electric)

DTE Energy's commercial 'Your Energy Savings Program' provides incentives to commercial and industrial customers who utilize energy efficiency upgrades in their facilities. Some energy efficient technologies eligible for this program include refrigerators, heat pumps, programmable thermostats, vending machine controls, and LED lighting. Custom incentives are based on estimated annual energy savings. Final applications are to be received within 60 days after project completion or by November 30 of the program's year, whichever comes first.

Commercial and Industrial Energy Efficiency Program (Gas)

DTE Energy's commercial 'Your Energy Savings Program' provides prescriptive incentives, mainly on a per unit basis. Some energy efficient technologies eligible for this program include water heaters, equipment insulations, boilers, tankless water heaters, steam system upgrades, windows/roofs, and several other pieces of equipment. Custom incentives are based on annual energy savings and apply to all energy efficiency improvement measures that are not eligible for a prescriptive incentive. The New Construction and Remodeling Program provide assistance in design and incentives for more efficient buildings that purchase and install energy-efficiency equipment.

Participants qualifying for energy efficiency measures in the DTE's service area can participate in the program only by having these measures installed in a business facility. This energy program will only pay incentives for energy saved in facilities in the DTE service areas. Final applications received within 60 days after project completion or by December 15 of the program year, whichever comes first.

Commercial New Construction Energy Efficiency Program

New construction and remodeling projects must entail a facility improvement that verifiable electrical savings (kWh) and/or natural gas energy savings (MCF). This utility rebate program provides incentives for comprehensive measures/whole buildings applicable in commercial, industrial, and construction sectors. Some incentives include: 10% - 20% energy savings: $0.08 per kWh and $4.00 per MCF, 20% - 30% energy savings: $0.10 per kWh and $6.00 per MCF, 30% or more energy savings: $0.12 per kWh and $8.00 per MCF. All non-prescriptive measures must pass a Total Resource Cost (TRC) Test.

4.4.1.3 Solar Programs

Solar Current Programs

Incentives through the Solar Currents program are offered to electric customers that install photovoltaic systems that have capacities within the range 1kW-20kW. For residential customers, the program offers both an up-front rebate of $0.20 per DC watt and a production incentive of $0.03 per kilowatt-hour (kWh) for the renewable energy credits (RECs) until August 31, 2029. Non-residential customers are eligible for incentives for photovoltaic equipment that are $0.13/Watt upfront and $0.02/Watt for the payment of Renewable Energy Credits (RECs).

This program is being offered as part of DTE Energy's compliance plan under the state Renewable Portfolio Standard. Funding for this will be in four rounds, with 500 kW of installations expected per round. Pricing is reviewed after each offering. For the first round of offerings, 1.5 MW is reserved for residential systems, and 0.5 MW is reserved for non-residential. The four application periods will open according to the following dates, respectively: 01/07/2013, 06/24/2013, 01/2014, and 06/2014.

4.4.2 Current Consumers Energy Efficiency Programs

Consumer Energy provides several energy efficiency programs regarding electric and gas for both commercial and residential markets.

4.4.2.1 Residential Programs

Residential Energy Efficiency Program (Electric)

Customers must install equipment in the Consumers Energy service area and receive electric service from Consumers Energy for the appliance purchased in order to apply for rebates. Heat pumps, central air conditioners, building insulation, and clothes washers are just several eligible pieces of equipment that can receive incentives.

Residential Energy Efficiency Program (Gas)

High efficiency furnaces, boilers, water heating units, insulation, windows, doors, energy audits and comprehensive improvements are eligible under this program. Residential Gas customers will be eligible to apply for a range of rebates.

4.4.2.2 Commercial Programs

Commercial Energy and Efficiency (Electric)

Incentives are available for energy efficiency equipment upgrades and are paid based on quantity, size, and efficiency of the equipment. Incentives are available for projects where the payback period is within 1 to 10 years. A bonus incentive of 15% may be available to customers who purchase equipment manufactured in Michigan.

Commercial Energy and Efficiency (Gas)

Incentives are available for energy efficiency equipment upgrades and are paid based on the quantity, size and efficiency of the equipment. Energy efficiency projects that have a payback year between 1-10 years may receive an incentive. A bonus incentive of 15% may be available to customers who purchase equipment manufactured in Michigan. Equipment measures not available for incentives are as follows: fuel switching, projects that involve peak-seeking, and changes in operational and/or maintenance practices.

5 POTENTIAL STUDY METHODOLOGY

This section describes the overall methodology that was utilized by GDS to develop the energy efficiency potential study for the State of Michigan. The main objective of this energy efficiency potential study is to quantify the technical, economic and achievable potential for electric and natural gas energy efficiency savings in Michigan. This report provides estimates of the potential kWh and kW electric savings and MMBtu gas savings for each level (technical, economic and achievable potential) of energy efficiency potential. This document describes the general steps and methods that were used at each stage of the analytical process necessary to produce the various estimates of energy efficiency potential. GDS did not examine delivery approaches for energy efficiency programs as this task was not included in the scope of work for this study.

Energy efficiency potential studies involve a number of analytical steps to produce estimates of each type of energy efficiency potential: technical, economic, and achievable. This study utilizes benefit/cost screening tools for the residential and non-residential sectors to assess the cost effectiveness of energy efficiency measures. These cost effectiveness screening tools are Excel-based models that integrate technology-specific impacts and costs, customer characteristics, utility avoided cost forecasts and more. Excel was used as the modeling platform to provide transparency to the estimation process and allow for simple customization based on Michigan's unique characteristics and the availability of specific model input data. The major analytical steps and an overview of the potential savings are summarized below, and specific changes in methodology from one sector to another have been noted throughout this section.

- Measure List Development
- Measure Characterization
- Load Forecast Development and Disaggregation
- Potential Savings Overview
- Technical Potential
- Measure Cost-Effectiveness Screening
- Economic Potential
- Achievable Potential

5.1 MEASURE LIST DEVELOPMENT

The energy efficiency measures included in this study cover energy efficiency measures included in the Michigan energy measures database (MEMD), additional measures suggested by interested stakeholders, as well as other measures based on the GDS Team's existing knowledge and current databases of electric and natural gas end-use technologies and energy efficiency measures. The study scope includes measures and practices that are currently commercially available as well as emerging technologies. The commercially available measures are of the most immediate interest to DSM program planners in Michigan. However, a small number of well documented emerging technologies were considered for each sector. Emerging technology research was focused on measures that are commercially available but may not be widely accepted at the current time. In June 2013, the GDS Team provided the energy efficiency measure lists for each sector to interested stakeholders for review and comment. These measure lists were then reviewed, discussed and updated as necessary. A complete listing of the energy efficiency measures included in this study is provided in the Appendices of this report.

In addition, this study includes measures that could be relatively easily substituted for, or applied to, existing technologies on a retrofit or replace-on-burnout basis. Replace-on-burnout applies to equipment replacements that are made normally in the market when a piece of equipment is at the end of its useful life. A retrofit measure is eligible to be replaced at any time in the life of the equipment or building. Replace-on-burnout measures are generally characterized by incremental measure costs and savings (*e.g.* the costs and savings of a high-efficiency versus standard efficiency air conditioner); whereas retrofit measures are generally characterized by full costs and savings (e.g. the full costs and savings associated with adding ceiling insulation into an existing attic). For new construction, energy efficiency measures can be implemented when each new home or building is constructed, thus the rate of availability is a direct function of the rate of new construction.

5.2 MEASURE CHARACTERIZATION

A significant amount of data is needed to estimate the kWh, kW and MMBtu savings potential for individual energy efficiency and demand response measures or programs across the entire existing residential and non-residential sectors in Michigan. GDS used Michigan specific data wherever it was available and up-to-date. Considerable effort was expended to identify, review, and document all available data sources.[15] This review has allowed the development of reasonable and supportable assumptions regarding: measure lives; measure installed incremental or full costs (as appropriate); and electric and natural gas savings and saturations for each energy efficiency measure included in the final list of measures in this study.

Costs and savings for new construction and replace on burnout measures are calculated as the incremental difference between the code minimum equipment and the energy efficiency measure. This approach is utilized because the consumer must select an efficiency level that is at least the code minimum equipment. The incremental cost is calculated as the difference between the cost of high efficiency and standard (code compliant) equipment. However, for retrofit measures, the measure cost was considered to be the "full" cost of the measure, as the baseline scenario assumes the consumer would do nothing. In general, the savings for retrofit measures are calculated as the difference between the energy use of the removed equipment and the energy use of the new high efficiency equipment (until the removed equipment would have reached the end of its useful life).

Savings: Estimates of annual measure savings as a percentage of base equipment usage were developed from a variety of sources, including:

- Michigan Energy Measures Database
- Secondary sources such as the American Council for an Energy-Efficient Economy ("ACEEE"), Department of Energy ("DOE"), Energy Information Administration ("EIA"), ENERGY STAR, Air Conditioning Contractors of America ("ACCA") and other technical potential studies and Technical Reference Manuals

Measure Costs: Measure costs represent either incremental or full costs, and typically include the incremental cost of measure installation. For purposes of this study, nominal measures costs were held constant over time. This general assumption is being made due to the fact that historically many measure costs (e.g., CFL bulbs, Energy Star appliances, etc.) have declined over time, while some measure costs have increased over time (e.g., fiberglass insulation). The one exception to this general assumption was that LED bulb costs were assumed to decline over time. This exception was included as directed by the Public Staff of the Michigan Public Service Commission (MPSC), and is grounded by the observation of rapidly declining LED bulb costs over the last several years, as well as the relatively high contribution of LED bulbs to the overall estimates of savings potential. Cost estimates were obtained from the following types of data sources:

- Michigan Energy Measures Database
- Secondary sources such as ACEEE, ENERGY STAR, NREL, NEEP Incremental Cost Study Report, and other technical potential studies and Technical Reference Manuals
- Retail store pricing (such as web sites of Home Depot and Lowe's) and industry experts

[15] The appendices and supporting databases to this report provide the data sources used by GDS to obtain up-to-date data on energy efficiency measure costs, savings, useful lives and saturations.

Measure Life: Represents the number of years that energy-using equipment is expected to operate. Useful life estimates have been obtained from the following data sources:

- Michigan Energy Measures Database
- Manufacturer data
- Savings calculators and life-cycle cost analyses
- Secondary sources such as ACEEE, ENERGY STAR, and other technical potential studies
- The California Database for Energy Efficient Resources ("DEER") database
- Evaluation reports
- GDS and other consultant research or technical reports

Baseline and Efficient Technology Saturations: In order to assess the amount of electric and natural gas energy efficiency savings still available, estimates of the current saturation of baseline equipment and energy efficiency measures, or for the non-residential sector the amount of energy use that is associated with a specific end use (such as HVAC) and percent of that energy use that is associated with energy efficient equipment are necessary. Up-to-date measure saturation data were primarily obtained from the following recent studies:

- 2011 Michigan Residential Baseline Study conducted by the MPSC
- Energy efficiency baseline studies conducted by DTE Energy and Consumers Energy
- 2011 Michigan Commercial Baseline Study conducted by the MPSC
- 2009 EIA Residential Energy Consumption Survey (RECS)
- 2007 American Housing Survey (AHS)
- 2010 EIA Manufacturing Energy Consumption Survey (MECS)
- 2003 EIA Commercial Building Energy Consumption Survey (CBECS)

Further detail regarding the development of measure assumptions for energy efficiency in the residential and non-residential sectors are provided in this report in later sections. Additionally, as noted above, the appendices of the report provide a comprehensive listing of all energy efficiency measure assumptions and data sources.

5.3 FORECAST DISAGGREGATION FOR THE COMMERCIAL AND INDUSTRIAL SECTORS

For the commercial sector, the baseline electric and natural gas load forecasts were disaggregated by combining sales breakdowns by business type provided by DTE Energy with regional energy use estimates by business type available from the U.S. Energy Information Administration (EIA)[16] The forecasts were then further disaggregated by end use based on end use consumption estimates for the East North Central Region (Michigan, Wisconsin, Ohio, Indiana, Illinois). The disaggregated electric and natural gas sales forecasts provide the foundation for the development of energy efficiency potential estimates for the commercial sector. It was not necessary to develop a disaggregated residential sales forecast because a bottom-up approach was used for the residential sector.

For the industrial sector, the baseline electric and natural gas demand forecasts were disaggregated by industry type and then by end use. The industry type breakdowns are based on Michigan value of shipments data and U.S. energy intensity data (consumption per $ of value shipped) by industry from the U.S. Census Bureau's Annual Survey of Manufacturers. Further dis-aggregation by end use is based on data from the EIA's 2010 Manufacturing Energy Consumption Survey (MECS) The disaggregated forecast data provides the foundation for the development of energy efficiency potential estimates for the industrial sector.

[16] 2003 EIA Commercial Building Energy Consumption Survey (CBECS), East North Central and Midwest Regions.

5.4 ROLE OF NATURALLY OCCURRING CONSERVATION

Naturally occurring conservation exists through government intervention, improved manufacturing efficiencies, building energy codes, market demand, and increased energy efficiency implementation by early adopters, who will implement measures without explicit monetary incentives. The impacts of new Federal government mandated energy efficiency standards have already been reflected in the baseline data for equipment unit energy consumption being used for this potential study. These new government standards, such as the new standards included in the Federal government's December 2007 Energy Independence and Security Act (EISA)[17], can significantly increase naturally occurring potential through tax incentives, stimulus funding or stricter manufacturing standards. These forces cause certain sector end-use energy consumption values to improve across the baseline forecast. It is important to account for these forces as thoroughly as possible to ensure the energy efficiency potential is not double-counted, by over-stating the potential that could occur for end-uses where codes and standards are reducing baseline unit energy consumption. In addition, GDS has reflected the impacts of new EISA lighting standards that went into effect starting in 2012, as well as changes to other federal baseline standards across a variety of end uses. These adjustments reduce energy efficiency potential starting in the years these standards come into effect, and in subsequent years.

5.5 POTENTIAL SAVINGS OVERVIEW

Potential studies often distinguish between several types of energy efficiency potential: technical, economic, and achievable. However, because there are often important definitional issues between studies, it is important to understand the definition and scope of each potential estimate as it applies to this analysis. The first two types of potential, technical and economic, provide a theoretical upper bound for energy savings from energy efficiency measures. Still, even the best designed portfolio of programs is unlikely to capture 100 percent of the technical or economic potential. Therefore, achievable potential attempts to estimate what may realistically be achieved, when it can be captured, and how much it would cost to do so. Figure 5-1 below illustrates the three most common types of energy efficiency potential.

Figure 5-1: Types of Energy Efficiency Potential[18]

Not Technically Feasable	Technical Potential		
Not Technically Feasable	Not Cost Effective	Economic Potential	
Not Technically Feasable	Not Cost Effective	Market & Adoption Barriers	Achievable Potential

5.6 TECHNICAL POTENTIAL

The GDS Team has used the energy efficiency potential definitions included on pages 2-4 of the November 2007 National Action Plan for Energy Efficiency (NAPEE) Guide for Conducting Energy Efficiency Potential Studies. Technical potential is the theoretical maximum amount of energy use that could be displaced by efficiency, disregarding all non-engineering constraints such as cost-effectiveness and the willingness of end-users to adopt the efficiency measures. It is often estimated as a "snapshot" in time assuming immediate implementation of all technologically feasible energy saving measures, with additional efficiency opportunities assumed as they arise from activities such as new construction.[19]

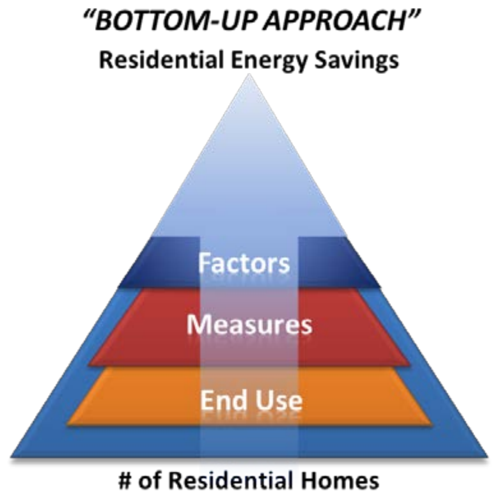
[17] PUBLIC LAW 110–140—DEC. 19, 2007. Energy Independence and Security Act of 2007

[18] Reproduced from "Guide to Resource Planning with Energy Efficiency" November 2007. US EPA. Figure 2-1.

[19] National Action Plan for Energy Efficiency, "Guide for Conducting Energy Efficiency Potential Studies", page 2-4

In general, this study utilizes a "bottom-up" approach in the residential sector to calculate the potential of an energy efficiency measure or set of measures as illustrated in Figure 5-2 below. A bottom-up approach was used for the residential sector due to the amount of data available for this sector from DTE Energy and Consumers Energy, from Federal government surveys and research done in nearby states. A bottom-up approach first starts with the savings and costs associated with replacing one piece of equipment with its high efficiency counterpart, and then multiplies these values by the number of measures available to be installed throughout the life of the program. The bottom-up approach is applicable in the residential sector because of better secondary data availability and greater homogeneity of the building and equipment stock to which measures are applied, compared to the non-residential sector. However, this methodology was not utilized in the non-residential sector. For the non-residential sector, a "top-down" approach was used for developing the technical potential estimates. The "top down" approach builds an energy use profile based on estimates of kWh sales by business segment and end use. Savings factors for energy efficiency measures are then applied to applicable end use energy estimates after assumptions are made regarding the fraction of sales that are associated with inefficient equipment and the technical/engineering feasibility of each energy efficiency measure.

Figure 5-2: Residential Sector Savings Methodology - Bottom Up Approach



As shown in Figure 5-2, the methodology starts at the bottom based on the number of residential customers (splitting them into single-family, multi-family and manufactured housing types as well as existing homes vs. new construction). From that point, estimates of the size of the eligible market in Michigan were developed for each energy efficiency measure. For example, energy efficiency measures that affect electric space heating are only applicable to those homes in Michigan that have electric space heating.

As noted previously, to obtain up-to-date appliance and end-use saturation data, the study made extensive use of the energy efficiency baseline studies provided by the MPSC, DTE Energy and Consumers Energy. The study relied primarily on the statewide baseline studies completed by Cadmus in 2011 for the commercial and residential sectors. The DTE and Consumers Energy baseline studies for the residential sector were used in a few instances because the utility baseline studies contained some details lacking in the statewide residential study. The surveys collected detailed data on the current saturation of electricity and natural gas consuming equipment in the DTE Energy and Consumers Energy service areas and the energy efficiency level of HVAC equipment, appliances, and building shell characteristics. Estimates of energy efficient equipment saturations were based on several sources, including data collected from the 2009 RECS and the baseline studies provided by the Michigan utilities.

The goal of the approach is to determine how many households that a specific measure applies to (base case factor), then of that group, the fraction of households/buildings which do not have the energy efficient version of the measure being installed (remaining factor). In instances where technical reasons do not permit the installation of the efficient equipment in all eligible households an applicability factor is used to limit the potential. Alternative water heating technologies (efficient water heater tanks, heat pump water heaters or solar water heating systems) are then utilized to meet the remaining market potential. The last factor to be applied is the savings factor, which is the percentage savings achieved from installing the efficient measure over a standard measure.

In developing the overall potential electricity savings, the analysis accounts for the interactive effects of measures designed to impact the same end-use. For instance, if a home were to properly seal all ductwork, the overall space heating and cooling consumption in that home would decrease. As a result, the remaining potential for energy savings derived from a heating/cooling equipment upgrade would be reduced. In instances where there are two (or more) competing technologies for the same electrical (or natural gas) end use, such as heat pump water heaters, water heater efficiency measures and high-efficiency electric storage water heaters, in most cases an equal percentage of the available population is assigned to each measure using the applicability factor[20]. In the event that one of the competing measures is not found to be cost-effective, the homes/buildings assigned to that measure are transitioned over any of the remaining cost effective alternatives.

The savings estimates per base unit are determined by comparing the high-efficiency equipment to current installed equipment for existing construction retrofits or to current equipment code standards for replace-on-burnout and new construction scenarios.

5.7 CORE EQUATION FOR THE RESIDENTIAL SECTOR

The core equation used in the residential sector energy efficiency technical potential analysis for each individual efficiency measure is shown below in Equation 5-1 below.

Equation 5-1: Core Equation for Residential Sector Technical Potential

$$\text{Technical Potential of Efficient Measure} = \text{Total Number of Households} \times \text{Base Case Equipment End Use Intensity} \times \text{Saturation Share} \times \text{Applicability Factor} \times \text{Savings Factor}$$

Where:

- **Total Number of Households** = the number of households in the market segment (e.g. the number of households living in detached single-family buildings)
- **Base Case Equipment End-use Intensity** = annual energy consumption (kWh or MMBtu) used per customer, per year, by each base-case technology in each market segment. This is the consumption of energy using equipment that efficient technology replaces or affects. This variable fully accounts for any known building characteristics in the service area, such as average square footage of homes in Michigan.
- **Saturation Share** = this variable has two parts: the first is the fraction of the end use energy that is applicable for the efficient technology in a given market segment. For example, for natural gas residential water heating, this would be the fraction of all residential gas customers that have gas water heating in their household; the second is the share of the end use gas energy that is applicable for the efficient technology that has not yet been converted to an efficient technology.

[20] GDS used its professional judgment in some cases to assign unequal applicability factors to attempt to avoid overstating or understating the potential of the set of competing technologies.

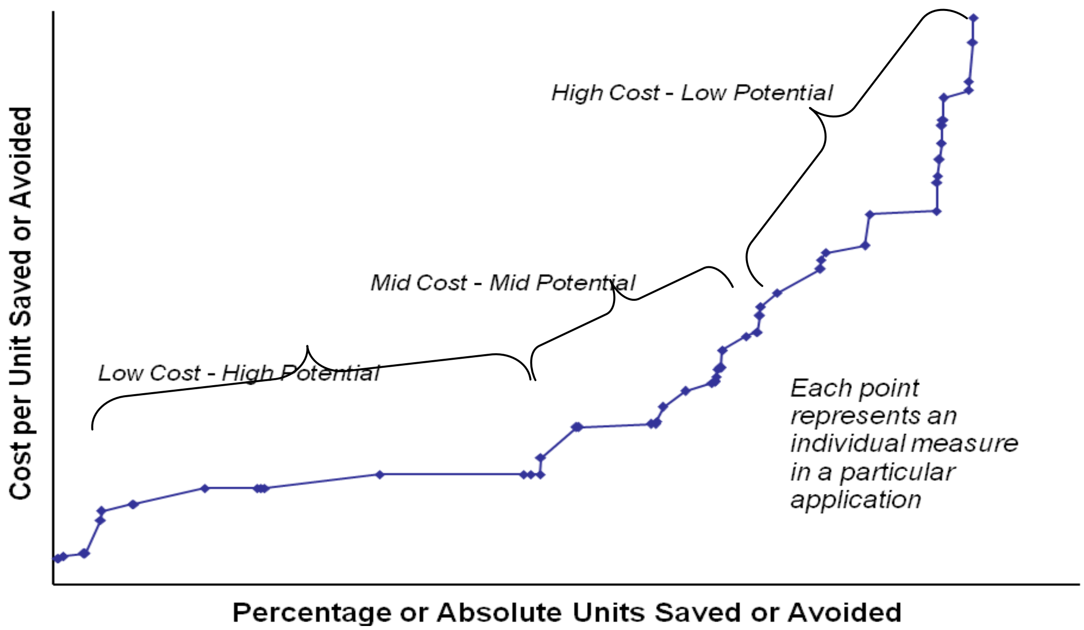
- **Applicability Factor** = this factor ensures that a household cannot receive two of the same type of measure. For example, if we assume there are two tiers of efficient natural gas furnaces, one which yields 10% savings and another which yields 20% savings, a household that needs to replace its inefficient natural gas furnace could either receive the unit which yields 10% savings or the unit which yields 20% savings, but could not receive both units. In general, GDS applies an even distribution to the same type of measure across eligible households when applying this factor. GDS may, in some cases, assign unbalanced applicability factors, if it believes an even distribution is inappropriate[21]. The applicability factor also captures the fraction of applicable units technically feasible for conversion to the efficient technology from an engineering perspective (e.g., it may not be possible to add wall insulation in all homes because the original construction of some homes does not allow for wall insulation to be installed without requiring major reconstruction of the house, which would be an additional cost that does not yield any energy benefits).
- **Savings Factor** = the percentage of energy consumption reduction resulting from application of the efficient technology. The savings factor is a general term used to illustrate the calculation of a measure's technical potential. The Excel-based model GDS uses fully integrates the necessary assumptions to determine the measure-level savings, given the **Base Case Equipment End-use Intensity**, and the expected savings of each technology.

Technical energy efficiency potential in the residential sector is calculated in two steps. In the first step, all measures are treated *independently*; that is, the savings of each measure are not reduced or otherwise adjusted for overlap between competing or interacting measures. By analyzing measures independently, no assumptions are made about the combinations or order in which they might be installed in customer buildings. However, the cumulative technical potential cannot be estimated by adding the savings from the individual savings estimates because some savings would be double-counted. For example, the savings from a measure that reduces heat loss from a building, such as insulation, are partially dependent on other measures that affect the efficiency of the system being used to heat the building, such as a high-efficiency furnace; the more efficient the furnace, the less energy saved from the installation of the insulation. In the second step, adjustments are made to account for such interactive effects. The adjustments for interactive effects were made by upgrading the baseline conditions while holding the savings percentages constant. The upgraded baseline conditions vary by measure and assume some measures (such as weatherization measures) are installed to increase the building efficiency prior to the installation of the measure that is subject to the baseline adjustment (ex. high efficiency furnaces).

Finally, the GDS Team has developed a supply curve to show the amount of energy efficiency savings available at different cost levels. The residential sector supply curve is included in an appendix of this report. A generic example of a supply curve is shown in Figure 5-3. As shown in the figure, a supply curve typically consists of two axes; one that captures the cost per unit of saving a resource (e.g., dollars per lifetime kWh or MMBtu saved) and another that shows the amount of savings that could be achieved at each level of cost. The curve is typically built up across individual measures that are applied to specific base-case practices or technologies by market segment. Savings measures are sorted based on a metric of cost. Total savings available at various levels of cost are calculated incrementally with respect to measures that precede them. Supply curves typically, but not always, end up reflecting diminishing returns, i.e., costs increase rapidly and savings decrease significantly at the end of the curve.

[21] For example, if historical data indicates a technology has been able to garner a large share of the market GDS may assign a higher applicability factor to this technology in order to properly reflect this knowledge.

Figure 5-3: Generic Example of a Supply Curve



As noted above, the cost portion of this energy efficiency supply curve is represented in dollars per unit of lifetime energy savings. Costs are annualized (often referred to as levelized) in supply curves. For example, electric energy efficiency supply curves usually present levelized costs per lifetime kWh saved by multiplying the initial investment in an efficient technology or program by the capital recovery rate (CRR), and then dividing that amount by annual kWh savings:

Therefore,

Levelized Cost per lifetime kWh Saved = Initial Cost x CRR/Annual kWh Savings

5.8 CORE EQUATION FOR THE COMMERCIAL SECTOR

The core equation utilized in the commercial sector technical potential analysis for each individual efficiency measure is shown below in Equation 5-2.

Equation 5-2: Core Equation for Commercial Sector Technical Potential

Where:

- **Total end-use kWh or natural gas sales by commercial sector and by building type** = the forecasted electric or natural gas sales level for a given end use (e.g., space heating) in a commercial or industrial industry type (e.g., office buildings or fabricated metals).
- **Base Case factor** = the fraction of end-use energy applicable for the efficient technology in a given commercial sector type. For example, with fluorescent lighting, this would be the fraction of all lighting kWh in a given industry type that is associated with fluorescent fixtures.

- **Remaining factor** = the fraction of applicable kWh or natural gas sales associated with equipment not yet converted to the electric or natural gas energy efficiency measure; that is, one minus the fraction of the industry type with energy efficiency measures already installed.
- **Convertible factor** = the fraction of the equipment or practice that is technically feasible for conversion to the efficient technology from an engineering perspective (e.g., it may not be possible to install variable-frequency drives (VFDs) on all motors.
- **Savings factor** = the fraction of electric or natural gas consumption reduced by application of the efficient technology.

For the commercial sector, the development of the energy efficiency technical potential estimate begins with a disaggregated energy sales forecast over the ten year forecast horizon (2013 to 2022). The commercial sector energy sales forecast is broken down by building type, then by electric or natural gas end use. Then a savings factor is applied to end use electricity or natural gas sales to determine the potential electricity or natural gas savings for each end use. The commercial sector, as defined in this analysis, is comprised of the following business segments:

- Warehouse
- Retail
- Grocery
- Office
- Lodging
- Healthcare
- Restaurant
- Institutional, including education
- Other

Similar to the residential sector, technical electric or natural gas energy efficiency savings potential in the commercial sector is calculated in two steps. In the first step, all measures are treated *independently*; that is, the savings of each measure are not reduced or otherwise adjusted for overlap between competing or synergistic measures. By treating measures independently, their relative economics are analyzed without making assumptions about the order or combinations in which they might be implemented in customer buildings. However, the total technical potential across measures cannot be estimated by summing the individual measure potentials directly because some savings would be double-counted. For example, the savings from a weatherization measure, such as low-e ENERGY STAR windows, are partially dependent on other measures that affect the efficiency of the system being used to cool or heat the building, such as high-efficiency space heating equipment or high-efficiency air conditioning systems; the more efficient the space heating equipment or electric air conditioner, the less energy saved from the installation of low-e ENERGY STAR windows. Accordingly, the second step is to rank the measures based on a metric of cost-effectiveness (using the Total Resource Cost test and Utility Cost Test cost effectiveness tests) and adjust savings for interactive effects so that total savings are calculated incrementally with respect to measures that precede them.

5.9 CORE EQUATION FOR THE INDUSTRIAL SECTOR

Estimating energy efficiency potential for the industrial sector can be more challenging than it is for the residential and commercial sectors because of the significant differences in the way energy is used across manufacturing industries (or market segments). How the auto industry uses energy is very different from how a plastics manufacturer does. Further, even within a particular industrial segment, energy use is influenced by the particular processes utilized, past investments in energy efficiency, the age of the facility, and the corporate operating philosophy.

Recognizing the variability of energy use across industry types and the significance of process energy use in the industrial sector, GDS employed a top-down approach that constructed an energy profile based on local economic data, national energy consumption surveys and any available Michigan studies related to industrial energy consumption.

5.10 INDUSTRIAL SECTOR SEGMENTATION & END USE BREAKDOWN

Estimates of energy efficiency potential were developed employing a top-down approach using economic data for key industrial segments (Primarily 3 digit NAICS codes) in Michigan to develop industry-specific energy use estimates based on national energy intensities for each industry. Value of shipments data for Michigan is available from the U.S. Census Bureau. This economic data was used in conjunction with energy use estimates from the 2010 Manufacturing Energy Consumption Survey[22] which is produced by the Energy Information Administration (EIA), to develop estimates of industrial electric and natural gas energy use by industry type and end use.

Industrial baseline energy consumption data was advanced to 2013 and future years based upon the observed historical trend in Michigan's industrial consumption and EIA's industrial electricity and natural gas consumption forecast for the U.S. (i.e., Annual Energy Outlook 2013).

End use electric and natural gas energy consumption estimates were calculated for the following end use categories for specific manufacturing segments:

- **Indirect Uses – Boilers**
  - Conventional boiler use
- **Direct Uses - Process**
  - Process heating (e.g., kilns, furnaces, ovens, strip heaters)
  - Process cooling & refrigeration
  - Machine drive
  - Electro-chemical processes
  - Other direct process use
- **Direct Uses – Non-process**
  - Facility heating, ventilation and air conditioning
  - Facility lighting
  - Other facility support (e.g., cooking, water heating, office equipment)
- **Other Non-process Use**

5.11 DEVELOPMENT OF POTENTIAL ESTIMATES

Estimates of industrial energy use by industry type and end use served as the foundation upon which energy efficiency potential estimates were calculated. The basic equation for determining technical potential is shown below.

The core equation for estimating technical potential in the industrial sector analysis for each measure is provided below:

Where:

[22] http://www.eia.gov/emeu/mecs/contents.html

- Total end-use sales by industry type = the forecasted electric or natural gas sales level for a given end use (e.g., space heating) by industrial industry type (e.g., fabricated metals, automobile manufacturing, paper and allied products, etc.).
- Base Case factor = the fraction of end-use energy applicable for the efficient technology in a given industry type. For example, with fluorescent lighting, this would be the fraction of all lighting kWh in a given industry type that is associated with fluorescent fixtures.
- Remaining factor = the fraction of applicable sales associated with equipment not yet converted to the electric energy-efficiency measure; that is, one minus the fraction of the industry type with energy-efficiency measures already installed.
- Convertible factor = the fraction of the equipment or practice that is technically feasible for conversion to the efficient technology from an engineering perspective (e.g., it may not be possible to install variable-frequency drives (VFDs) on all motors.
- Savings factor = the fraction of energy consumption reduced by application of the efficient technology.

5.12 ECONOMIC POTENTIAL

Economic potential refers to the subset of the technical potential that is economically cost-effective (based on screening with the cost effectiveness tests utilized for this Michigan study) as compared to conventional supply-side energy resources. GDS has calculated the benefit/cost ratios for this study according to the cost effectiveness test definitions provided in the November 2008 National Action Plan for Energy Efficiency (NAPEE) guide titled "Understanding Cost Effectiveness of Energy Efficiency Programs". Both technical and economic potential are theoretical numbers that assume immediate implementation of energy efficiency measures, with no regard for the gradual "ramping up" process of real-life programs. In addition, they ignore market barriers to ensuring actual implementation of energy efficiency. *Finally, they typically only consider the costs of efficiency measures themselves, ignoring any programmatic costs (e.g., marketing, analysis, administration, program evaluation, etc.) that would be necessary to capture them.*

Furthermore, all measures that were not found to be cost-effective based on the results of the measure-level cost effectiveness screening were excluded from the economic and achievable potential. Then allocation factors were re-adjusted and applied to the remaining measures that were cost effective.

5.13 DETERMINING COST-EFFECTIVENESS

GDS Team examined measure cost effectiveness scenarios based on the Total Resource Cost (TRC) test and the Utility Cost Test.

Total Resource Cost Test[23]

The TRC measures the net benefits of the energy efficiency program for the region as a whole. Costs included in the TRC are costs to purchase and install the energy efficiency measure and overhead costs of running the energy efficiency program, regardless of who pays these costs. The benefits included are the avoided costs of energy (as with the Utility Cost Test and the Rate Impact Measure Test) as well as non-energy benefits. GDS did include a benefit of $9.25 per ton of reduced carbon emission. This risk adjusted value represents the expected value of a scenario with no carbon taxes and a scenario with carbon taxes of $18.50 per ton.

The primary purpose of the TRC test is to evaluate the net benefits of energy efficiency measures to the region or State as a whole. Unlike the Utility Cost Test, the Rate Impact Measure (RIM) test or the Participant Cost Test (PCT), the TRC does not take the view of individual stakeholders. It does not

[23] It is important to note that the Michigan PSC staff, GDS Associates and staff from DTE Energy and Consumers Energy decided not to include any unquantifiable non-energy benefits in the calculation of the TRC Test (beyond savings water, avoided carbon emissions, and O&M savings). While other non-energy benefits may be present, they have not been quantified in the state of Michigan and were not available for inclusion in this study.

include bill savings and incentive payments, as they yield an intra-regional transfer of zero ("benefits" to customers and "costs" to the utility that cancel each other on a regional level). For some utilities, the region considered may be limited strictly to its own service territory, ignoring benefits (and costs) to neighboring areas (a distribution-only utility may, for example, consider only the impacts to its distribution system). In other cases, the region is defined as the state as a whole, allowing the TRC to include benefits to other stakeholders (e.g., other utilities, water utilities, local communities). The TRC is useful for jurisdictions wishing to value energy efficiency as a resource not just for the utility, but for the entire region. Thus the TRC is the most frequently used primary test in the United States. The TRC may be considered the sum of the PCT and RIM, that is, the participant and non-participant cost-effectiveness tests. The TRC is also useful when energy efficiency might fall through the cracks taken from the perspective of individual stakeholders, but would yield benefits on a wider regional level

Utility Cost Test

The Utility Cost Test (UCT) examines the costs and benefits of an energy efficiency program from the perspective of the entity implementing the program (utility, government agency, nonprofit, or other third party). GDS set incentives at 50% of measure costs when calculating the UCT. When conducting screening at the measure level, GDS only included utility costs relating to the equipment cost. For program or portfolio screening, GDS included all costs incurred by the utility. Overhead costs include the utility's administration, marketing, research and development, evaluation, and measurement and verification costs. Incentive costs are payments made to the utility's customers to offset purchase or installations costs. The benefits from the utility perspective are the savings derived from not delivering the energy to customers. Depending on the jurisdiction and type of utility, the "avoided costs" can include avoided or reduced wholesale electricity or natural gas purchases, generation costs, power plant construction, transmission and distribution facilities, ancillary service and system operating costs, and other components.

Table 5-1 below shows the key assumptions used by GDS in the development of the economic and achievable potential estimates based upon cost effectiveness screening using the Total Resource Cost (TRC) test and the Utility Cost test (UCT):

Table 5-1: Key Assumptions Used by GDS in the Development of Measure-Level Screening

KEY ASSUMPTION	USED IN UCT SCREENING	USED IN TRC SCREENING
Utility weighted average cost of capital for the discount rate	Yes	Yes
Forecasts of electric and natural gas energy and capacity avoided costs provided to GDS by the staff of the Michigan Public Service Commission	Yes	Yes
Forecast of electric T&D avoided costs per kW/year based on 2009 study by the New York Public Service Commission	Yes	Yes
Average line losses provided by Michigan utilities	Yes	Yes
MISO planning reserve margin	Yes	Yes
Electricity and natural gas savings benefits both valued in the cost effectiveness test for electric or natural gas energy efficiency programs	Yes	Yes
Value of avoided bulb purchases for high efficiency light bulbs	No	Yes
Water savings where applicable	No	Yes

KEY ASSUMPTION	USED IN UCT SCREENING	USED IN TRC SCREENING
Tax credits	No	Yes
Non-energy benefits (adder of $9.25 per ton of carbon emissions avoided)	No	Yes

Based on discussions with DTE Energy, Consumers Energy and staff of the Michigan Public Service Commission during October 2013, GDS has used average line losses to adjust kWh and kW savings at the customer meter to the generation level of the electric grid. DTE Energy and Consumers Energy recognize that in theory it would be appropriate to use marginal line losses instead of average line losses for this adjustment of savings. Because no studies or data exist at DTE Energy or Consumers Energy relating to marginal line losses on the Michigan electric grid, the study Team decided to use average line losses.

Financial Incentives for Program Participants

There are several reasons why an incentive level of 50% of measure costs (and not 100% of measure costs) was assumed for the three achievable potential scenarios examined for this study:

1. First, an incentive level of 50% of measure costs assumed in this study for the three achievable potential scenarios is a reasonable target based on the current financial incentive levels for program participants used by DTE Energy and Consumers Energy for their existing energy efficiency programs.

2. Second, GDS has reviewed other energy efficiency potential studies conducted in the US. The incentive levels used in several studies reviewed by GDS as well as actual experience with incentive levels in other states confirm that an incentive level assumption of 50% or below is commonly used.[24] Also, the majority of energy efficiency programs offered by NYSERDA offer no incentives to consumers. In addition, the NYSERDA electric energy efficiency achievable potential study completed by Optimal Energy in 2006 assumed incentive levels in the range of 20% to 50%.

3. Third, and most important, the highly recognized 2004 National Energy Efficiency Best Practices Study concluded that use of an incentive level of 100% of measure costs is not recommended as a program strategy.[25] This national best practices study concluded that it is very important to limit incentives to participants so that they do not exceed a pre-determined portion of average or customer-specific incremental cost estimates. The report states that this step is critical to avoid grossly overpaying for energy savings. This best practices report also notes that if incentives are set too high, free-ridership problems will increase significantly. Free riders dilute the market impact of program dollars.
4. Fourth, financial incentives are only one of many important programmatic marketing tools. Program designs and program logic models also need to make use of other education, training and marketing tools to maximize consumer awareness and understanding of energy efficient products. A program manager can ramp up or down expenditures for the mix of marketing tools to maximize program participation and savings. The February 2010 National Action Plan for Energy Efficiency Report titled "Customer Incentives for Energy Efficiency Through Program

[24] GDS Associates October 25, 2013 survey of financial incentives used in energy efficiency programs implemented by Consumers Energy, DTE Energy, Ameren-Illinois, Efficiency Maine, Wisconsin Focus on Energy, and Xcel Energy (Minnesota).

[25] See "National Energy Efficiency Best Practices Study, Volume NR5, Non-Residential Large Comprehensive Incentive Programs Best Practices Report", prepared by Quantum Consulting for Pacific Gas and Electric Company, December 2004, page NR5-51.

Offerings" states on page 1 that "Incentives can be used in conjunction with other program strategies to achieve market transformation, whereby there is a lasting change in the availability and demand for energy-efficient goods and services." On page 11 of this report it is stated that "Well-designed incentives address the key market barriers in the target market. Financial incentives are designed to be just high enough to gain the desired level of program participation. In some cases, financial incentives can be bundled with financing, information, or technical services to reach program participation and energy savings goals at lower total program cost than using financial incentives alone."

5.14 ACHIEVABLE POTENTIAL

Achievable potential was determined as the amount of energy and demand that can realistically be saved assuming an aggressive program marketing strategy and with three scenarios. Achievable potential takes into account barriers that hinder consumer adoption of energy efficiency measures such as financial, political and regulatory barriers, and the capability of programs and administrators to ramp up activity over time. This potential study evaluates three achievable potential scenarios:

4) **Scenario #1**: For the first scenario, achievable potential represents the amount of energy use that efficiency can realistically be expected to displace assuming incentives equal to 50% of the incremental measure cost and no spending cap. Cost effectiveness of measures was determined with the Utility Cost Test. The long-term market penetration for Scenario #1 was estimated based on the utilities paying incentives equal to 50% of measure costs. Year-by-year estimates of achievable potential for the period 2014 to 2023 were estimated by applying market penetration curves to this long-term penetration rate estimate. In general, these curves were developed based on willingness to pay data collected through survey research. Although this simplifies what an adoption curve would look like in practice, it succeeds in providing a concise method for estimating achievable savings potential over a specified period of time.

5) **Scenario #2**: For the second scenario, achievable potential is based on measure cost effectiveness screening using the Total Resource Cost Test with utility incentives again equal to 50% of measure costs. GDS calculated the savings and costs associated with the 50% incentive level. Year-by-year estimates of achievable potential for the period 2014 to 2023 were estimated by applying market penetration curves to this long-term penetration rate estimate. Any differences between Achievable Scenario #1 and Achievable Scenario #2 result from the varied measures that pass the Utility Cost Test compared to the Total Resource Cost Test

6) **Scenario #3**: The third scenario is a subset of Achievable Scenario #1(based on UCT). While scenario #1 assumed no spending cap on efficiency measures, Achievable Scenario #3 assumed a spending cap of approximately 2% of utility revenues. Revenues are apportioned across each customer sector to prevent cross-subsidization of energy efficiency savings. GDS has not attempted to define specific program plans. Instead the market adoption assumptions from Achievable Scenario #1 have been scaled down to fit within the spending parameters.

While many different incentive scenarios could be modeled, the number of achievable potential scenarios that could be developed was limited to three scenarios due to the available budget for this potential study[26].

For new construction, energy efficiency measures can be implemented when each new home or building is constructed, thus the rate of availability is a direct function of the rate of new construction. For existing buildings, determining the annual rate of availability of savings is more complex. Energy

[26] None of the three scenarios is considered a "maximum" achievable scenario. Maximum achievable scenarios assume 100% incentives. The three scenarios included in the report assume 50% incentives. This approach approximates the level incentives currently offered by Michigan utilities.

efficiency potential in the existing stock of buildings can be captured over time through two principal processes:

1) As equipment replacements are made normally in the market when a piece of equipment is at the end of its effective useful life (referred to as "replace-on-burnout")
2) At any time in the life of the equipment or building (referred to as "retrofit")

For the replace-on-burnout measures, existing equipment is assumed to be replaced with high-efficiency equipment at the time a consumer is shopping for a new appliance or other energy consuming equipment, or if the consumer is in the process of building or remodeling. Using this approach, only equipment that needs to be replaced in a given year is eligible to be upgraded to energy efficient equipment. For the retrofit measures, savings can theoretically be captured at any time; however, in practice, it takes many years to retrofit an entire stock of buildings, even with the most aggressive of energy efficiency programs.

5.15 MARKET PENETRATION METHODOLOGY

GDS assessed achievable potential on a measure-by-measure basis. In addition to accounting for the natural replacement cycle of equipment in the achievable potential scenario, GDS estimated measure specific maximum adoption rates that reflect the presence of possible market barriers and associated difficulties in achieving the 100% market adoption assumed in the technical and economic scenarios. The methodology utilized to forecast participation within each customer sector is described below.

RESIDENTIAL

As noted earlier in the report, there are approximately 1,900 residential measures included in this study. Due to the wide variety of measures across multiple end-uses, GDS employed varied, measures-specific maximum adoption rates versus a singular universal market adoption curve. These long-term market adoption estimates were based on publicly available DSM research including market adoption rate surveys and other utility program benchmarking.[27] GDS acknowledges that reliance on additional studies and alternate methods could produce different estimates of achievable potential.

For the majority of residential measures, the analysis assumes that increased incentives and reduced participant costs will also reduce the simple payback period of energy efficiency measures. As incentives increase and payback periods decline, maximum market adoption rates will increase. Based on available market adoption surveys with program administrators in the Northeast, GDS assigned end-use specific market adoption curves to the residential measures included in this analysis.[28] Examples of the impact of incentives on payback and maximum market adoption rates are demonstrated in the table below. These curves reflect measures that have significant gas and electric achievable potential over the next 10 years.[29]

Once the long-term market adoption rate was determined, GDS estimated the time interval required to reach the ultimate maximum adoption rate. In general, measures that required less up-front cost from

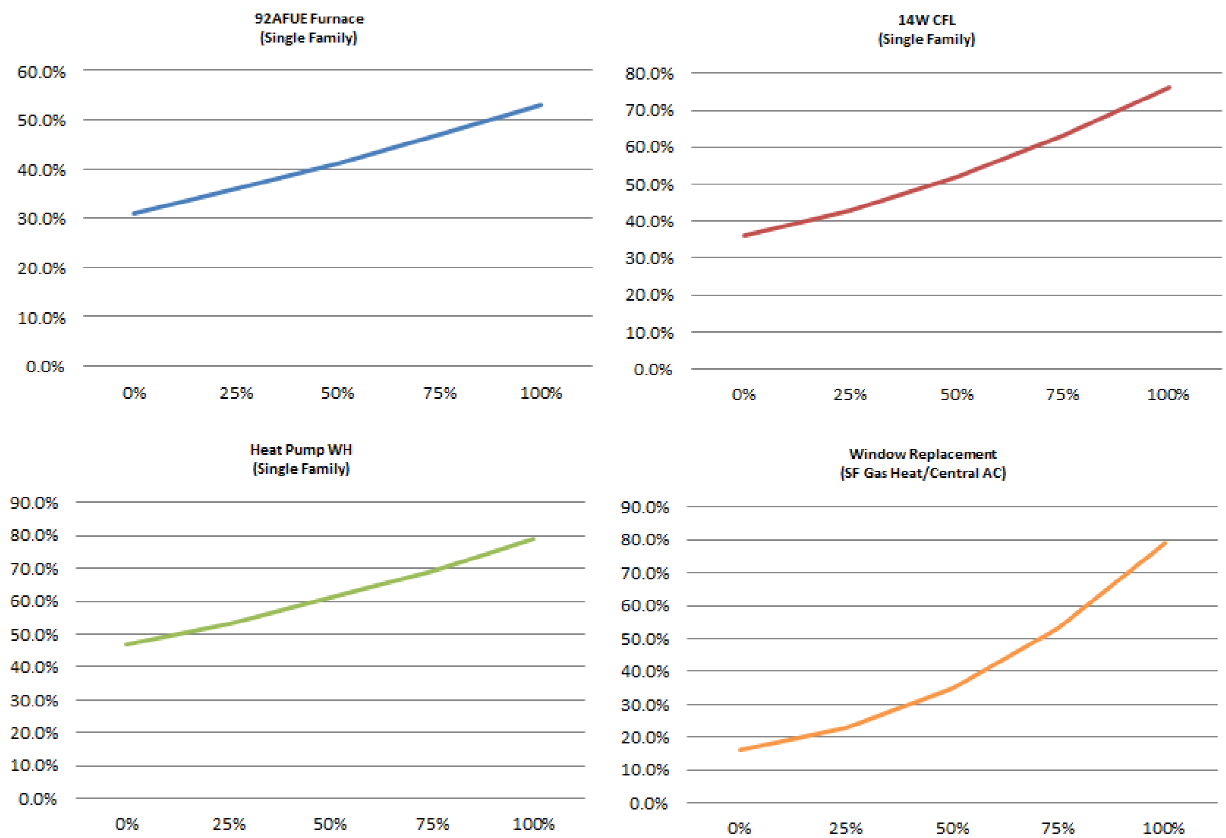
[27] Massachusetts Multifamily Market Characterization and Potential Study Volume I. May 2012. Cadmus Group. & Appliance Recycling Program Process Evaluation and Market Characterization. Volume I. CALMAC Study ID# SCE0337.01. September 2012. Cadmus.

[28] Massachusetts Multifamily Market Characterization and Potential Study Volume I. May 2012. Cadmus Group. This study presents market adoption curves based on the perspective of both multifamily property managers as well as utility energy efficiency program administrators. Both groups of study participants provide support for the contention that increased incentives/reduced payback result in higher maximum adoption rates. GDS selected the adoption curves based on the feedback of program administrators…. GDS encourages Michigan to conduct similar research with program participants and program administrators to refine these market adoption estimates in future analyses.

[29] Where current energy efficiency saturation data exceeded the estimated maximum market adoption, GDS assumed future efficiency installations would occur at the current EE saturation percentage so that the long-term market saturation of energy efficiency measures would not decrease over the study time-frame.

the participant reached their maximum adoption rate over a period of 2-3 years, and continued at the maximum rate for the remainder of the study. Measures with a more substantial cost to the participant required more time to ramp-up, and would not reach their maximum adoption rate until later in the study period. GDS exercised its professional judgment in estimating the time to reach the ultimate market adoption rate.

Figure 5-4: Example Residential Maximum Adoption Rates – Based on Incentive



One caveat to this approach is that the ultimate long-term adoption rate is generally a simple function of incentive levels and payback. There are many other possible elements that may influence a customer's willingness to purchase an energy efficiency measure. For example, increased marketing and education programs can have a critical impact on the success of energy efficiency programs. Additionally, other perceived measure benefits, such as increased comfort or safety as well as reduced maintenance costs could also factor into a customer's decision to purchase and install energy efficiency measures. Although these additional elements are not explicitly accounted for under this incentive/payback analysis, the estimated adoption rates and penetration curves provide a concise method for estimating achievable savings potential over a specified period of time.

The market penetration of residential lighting was also strategically adjusted to account for the expected decline in LED bulbs costs over the next decade and an anticipated shift in market adoption from CFL bulbs to LED bulbs. Because LED bulb prices are expected to decline significantly over the next several years, decreasing to typical CFL bulb incremental cost levels, GDS assumed the maximum adoption rate for LED bulbs to be similar to those used for CFL bulbs. Additionally, GDS relied on future unit penetration rates for various lighting sources to model the long term shift towards increased market penetration of LED bulbs compared to CFL bulbs.[30] The table below shows the year-by-year shifting market penetration of CFL and LED bulbs estimated in this analysis. By 2018, LED bulbs are expected to be installed at a greater rate than their CFL counterparts.

[30] Fox, Jamie. Does LED Lighting Have a Tipping Point? IMS Research. April 2012.

Table 5-2. CFL vs. LED Market Penetration Share of Anticipated High Efficiency Residential Lighting Installations

	2014	2015	2106	2017	2018	2019	2020	2021	2022	2023
CFL	32%	39%	45%	50%	53%	58%	64%	66%	68%	70%
LED	68%	61%	55%	50%	47%	42%	36%	34%	32%	30%

Last, for appliance recycling measures GDS compared the harvest rate (total number of recycled appliances relative to the total residential population) of several utility appliance recycling programs nationwide. Based on each utilities most successful reported year, an average harvest rate for various appliance recycling measures was estimated. GDS then calculated a long-term market adoption rate for the appliance recycling measures that would create a similar harvest rate for Michigan's appliance recycling programs. Because appliance recycling programs do not require any participants costs and require customer willingness to remove secondary, operational equipment from their homes, this approach was selected in favor of the incentive/payback curves utilized for the more traditional rebated measures included in the analysis.

NON-RESIDENTIAL

The non-residential approach for estimating market adoption rates is very similar to the residential sector approach. GDS employed varied, measures-specific maximum adoption rates versus a singular universal market adoption curve. These long-term market adoption estimates were based on the following survey results reported in the 2010 DTE Electric and Natural Gas Potential Study.[31] That study reported the following results:[32]

Table 5-3. Adoption Factors by Equipment and Incentive Level

EQUIPMENT TYPE	0%	50%	75%	100%
Lighting	54%	66%	70%	75%
AC / HVAC	49%	63%	68%	74%
Motors	58%	69%	73%	77%
Variable Speed	47%	66%	67%	69%
Refrigeration	57%	65%	71%	76%
Energy Mgmt System	44%	59%	67%	74%
Food Service	49%	66%	69%	73%
Process Measures	57%	65%	67%	69%
Water Heating	56%	67%	74%	80%
Overall	**52%**	**65%**	**69%**	**74%**

GDS used the data shown above to estimate long term market penetration for commercial and industrial (process) measures based on the assumed incentive level stated as a percent of incremental cost. GDS assumed two different paths to achieving long term market penetration, one for full cost measures such as insulation and another for incremental cost measures such as energy efficient fluorescent lighting. Those paths are shown below in Table 5-4.

Table 5-4: Path to Achieving Long Term Market Penetration (% of Long Term Market Potential)

[31] Assessment of Nonresidential Electric and Natural Gas Energy Efficiency Potential (2010–2029), Prepared for DTE Energy by The Cadmus Group, Inc.
[32] Ibid., p. 35.

YEAR	1	2	3	4	5	6	7	8	9	10
Full Cost Measure	5%	15%	20%	20%	10%	10%	5%	5%	5%	5%
Incremental Cost Measure	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%

As with the residential approach, the non-residential market penetration methodology uses the relationship between incentives and program participation as a concise quantitative method for estimating achievable savings potential over a specified period of time. While there are many other elements that may influence a business customer's willingness to install an energy efficiency measure, such as access to capital, corporate policy or reduced maintenance costs, these factors are difficult to quantify and fit into a forecasting approach.

6 RESIDENTIAL ELECTRIC AND NATURAL GAS ENERGY EFFICIENCY POTENTIAL ESTIMATES

This section provides electric and natural gas energy efficiency potential estimates for the residential sector in Michigan which includes all residential buildings. Estimates of technical, economic and achievable potential are provided. Electric and natural gas potential are presented as separate sections, but interactive effects and measures that yield both electric and natural gas savings are fully accounted for in the analysis.

6.1 RESIDENTIAL ELECTRIC POTENTIAL

According to 2011 historical sales data, the residential sector accounts for approximately 89% of total customers and 33% of total energy sales. The average residential consumer uses approximately 7,900 kWh per year. From 2002-2011, the residential sector sales and customers have experienced minimal growth. This analysis assumes residential MWh sales increase at roughly 0.25% annually based upon the based on Michigan utility load forecasts. The residential electric potential calculations are based upon these approximate consumption values and sales forecast figures over the time horizon covered by the study. The potential is calculated for the entire residential sector and includes breakdowns of the potential associated with each end use.

6.1.1 Energy Efficiency Measures Examined

For the residential sector, there were 1119 total electric savings measures included in the potential energy savings analysis[33]. Table 6-1 provides a brief description of the types of measures included for each end use in the residential model. The list of measures was developed based on a review of the Michigan Energy Measure Database (MEMD) and measures found in other residential potential studies and TRMs from the Midwest. Measure data includes incremental costs, electricity energy and demand savings, gas and water savings, and measure life.

Table 6-1: Measures and Programs Included in the Electric Residential Sector Analysis

END USE TYPE	END USE DESCRIPTION	MEASURES INCLUDED
HVAC Envelope	Building Envelope Upgrades	• Air/duct Sealing • Duct Insulation • Improved Insulation (Wall, Ceiling, and Floor) • Efficient Windows • Window Film • ENERGY STAR Doors • Cool Roofs • Low Income Weatherization Package
HVAC Equipment	Heating/Cooling/Ventilation Equipment	• Existing Central AC Tune-Up • Efficient Air-Source Heat Pump • Dual Fuel Heat Pumps • Geothermal Heat Pumps • Ductless Mini-split Systems • Efficient Central AC Systems • Programmable Thermostats • Efficient Room Air Conditioners • Room Air Conditioner Recycling

[33] This total represents the number of unique electric energy efficiency measures and all permutations of these unique measures. For example, there are 76 permutations of the “Improved Duct Sealing” measure to account for the various housing types, heating/cooling combinations, and construction types.

END USE TYPE	END USE DESCRIPTION	MEASURES INCLUDED
		• Whole House Fans • Efficient Chillers • Chiller Controls • Efficient Furnace Fans
Water Heating	Domestic Hot Water	• Heat Pump Water Heater • Solar Water Heater • Low Flow Showerhead/Faucet Aerator • Gravity Film Heat Exchangers • Pipe Wrap • Tank Wrap
Lighting	Interior/Exterior Lighting	• Specialty CFLs • Standard CFLs • LED Lighting • Efficient Exterior Lighting • Efficient Torchiere Lamps • Efficient Fluorescent Tube Lighting • LED Night Lights • Occupancy Sensors • Holiday Lighting • Efficient Multifamily Common Area Lighting
Appliances	High-Efficiency Appliances / Retirement of Inefficient Appliances	• ENERGY STAR Clothes Washers • ENERGY STAR Refrigerator • ENERGY STAR Freezers • ENERGY STAR Dishwashers • ENERGY STAR Dehumidifiers • Heat Pump Dryers • Secondary Refrigerator/Freezer Turn-In • 2nd Dehumidifier Turn-In
Electronics	High Efficiency Consumer Electronics	• Controlled Power Strips • Efficient Set-Top Boxes • ENERGY STAR Desktops • Efficient Laptops • Efficient Televisions • LCD Monitors
Behavioral	Consumer Response to Feedback from Utility	• Direct (Real-Time) Feedback • Indirect Feedback
Other	Efficient Pool Equipment	• Efficient Pool Pump Motors

6.1.2 Overview of Residential Electric Energy Efficiency Potential

This section presents estimates for electric technical, economic, and achievable potential for the residential sector. Each of the tables in the technical, economic and achievable sections present the respective potential for efficiency savings expressed as cumulative annual energy savings (MWh), percentage of savings by end use, and savings as a percentage of forecast sales. Data is provided on a 5-year and 10-year time horizon for Michigan.

This energy efficiency potential study considers the impacts of the Energy and Independence and Security Act (EISA) as an improving code standard for the residential sector. The EISA improves the baseline efficiency of several types of lighting products, including CFL or LED bulbs. Other known increases to federal minimum efficiency standards over the time period studied have also been accounted for in the analysis. These included changes to the efficiency standards central air conditioners, electric water heaters, and appliances.

There are a variety of factors which contribute to uncertainty surrounding the savings estimates produced by this energy efficiency potential study. These factors can include the following:

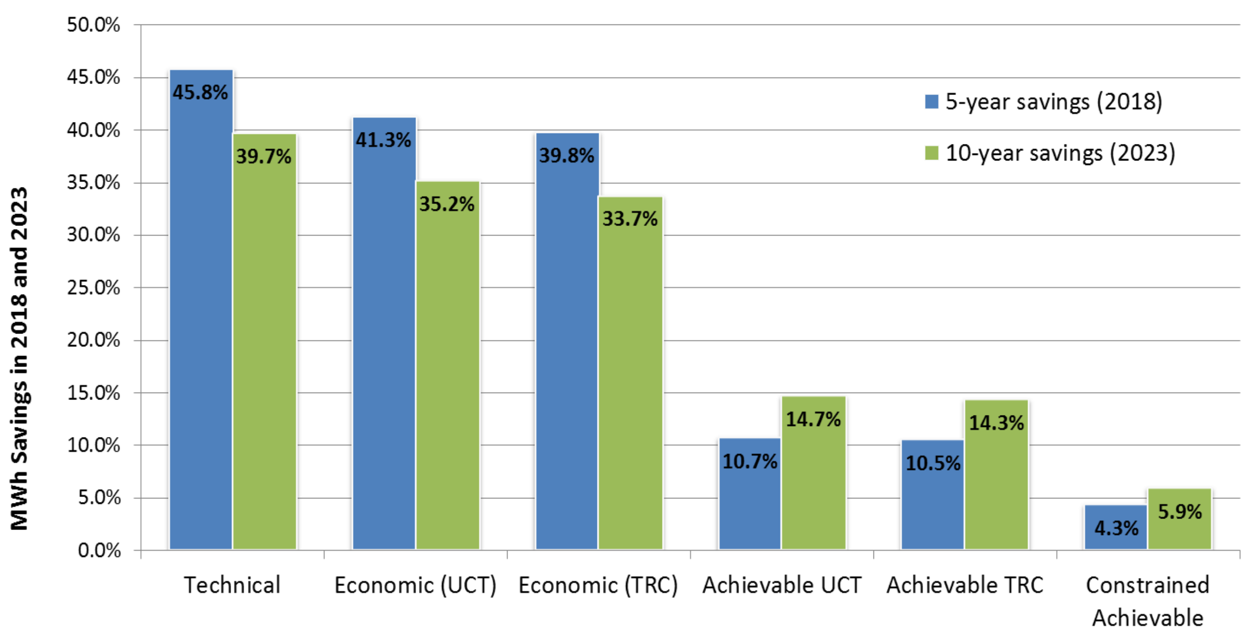
- Uncertainty about economic and fuel price forecasts used as inputs to the electric and natural gas sales forecasts
- The accuracy of results generated by building energy simulation modeling software
- The lack of availability of up-to-date efficiency saturation data for Michigan
- Changes to codes and standards in the future which cannot be anticipated at the present time, and
- Uncertainty regarding the future adoption of energy efficiency technologies which have minimal market share at the present time, such as LED lighting.

GDS has addressed the areas of uncertainty as robustly as possible given the time and budget constraints of this project. For example, GDS assumes increasing market adoption of LEDs over the life of the study because LED costs are expected to decrease over time. GDS also assimilated baseline study data into the estimates of weather sensitive measure savings where possible to adjust values acquired from the MEMD. These adjustments apply to measures such as insulation, for which savings are provided on a square footage basis in the MEMD. Weather-sensitive measure savings estimates from the MEMD were also adjusted to account for known changes to federal standards.

SUMMARY OF FINDINGS

Figure 6-1 illustrates the estimated savings potential for each of the scenarios included in this study.

Figure 6-1: Summary of Residential Electric Energy Efficiency Potential as a % of 2018 and 2023 Sales Forecasts



The potential estimates are expressed as cumulative 5-year and 10-year savings, as percentages of the respective 2018 and 2023 sector sales. The technical potential is 45.8% in 2018 and 39.7% in 2023.[34] The 5-year and 10-year economic potential is 41.3% and 35.2% based on the Utility Cost Test (UCT) screen, assuming an incentive level equal to 50% of the measure cost. Based on a measure-level screen using the TRC Test, the economic potential is 39.8% in 2018 and 33.7% in 2023. The slight drop from technical potential to economic potential indicates that most measures are cost-effective, particularly when screening based on the UCT.

The 5-year and 10-year achievable potential savings are: 10.7% and 14.7% for the Achievable UCT scenario; 10.5% and 14.3% for the Achievable TRC scenario; and 4.3% and 5.9% for the Constrained Achievable scenario. The Achievable UCT scenario assumes 50% incentives and includes measures that passed the UCT Test. The Achievable TRC scenario also assumes 50% incentives but includes only measures that passed the cost-effectiveness screen based on the TRC Test. Last, the Constrained Achievable scenario is a subset of Achievable UCT scenario, assuming a spending cap on DSM approximately equal to 2% of future annual residential revenue from electric and gas retail sales.

TECHNICAL POTENTIAL

Technical potential represents the quantification of savings that can be realized if all technologically available energy-efficiency measures are immediately adopted in all feasible instances, regardless of cost. Table 6-2 shows that it is technically feasible to save nearly 15.5 million MWh in the residential sector between 2014 to 2018, as well as approximately 13.7 million MWh during the 10 year period from 2014 to 2023 statewide, representing 45.8% of 5-year residential sales, and 39.7% of 10-year residential sales.[35] Lighting represents the greatest contributor to the potential at 42-33% of savings, while Appliances, Electronics, and HVAC Equipment end uses each contribute 9-21% of the savings. Table 6-3 shows the demand savings potential in 2018 and 2023. The five and ten year summer peak demand savings potential is 4,274 MW and 4,138 MW, respectively, which is 42.7% and 40.5% of the peak forecast.

Table 6-2: Residential Sector Technical Potential Energy Savings by End Use

END USE	2018 ENERGY (MWH)	% OF 2018 SAVINGS	2023 ENERGY (MWH)	% OF 2023 SAVINGS
Appliances	1,915,506	12%	1,931,055	14%
Electronics	1,354,281	9%	1,392,980	10%
Lighting	6,561,055	42%	4,567,580	33%
Water Heating	1,350,089	9%	1,393,193	10%
Other	178,956	1%	182,695	1%
HVAC (Envelope)	888,701	6%	914,396	7%
HVAC (Equipment)	2,806,002	18%	2,879,504	21%
Behavioral Programs	427,140	3%	436,525	3%
Total	**15,481,730**	**100%**	**13,697,929**	**100%**
% of Annual Sales Forecast	*45.8%*		*39.7%*	

[34] Technical and Economic Potential may decrease in 2023, relative to 2018, due to the expected impacts of EISA and a 2020 provision that is expected to make CFL bulbs, or technology of similar efficacy, the baseline. As a result, all savings associated with CFL bulbs replacing general service incandescent were modeled to decrease to 0 kWh by 2021.

[35] Technical potential represents the potential for all inefficient measures to be implemented "over-night." The only growth in potential over the 5 and 10 year time period is related to new construction. As noted in the prior footnote, CFLs were expected to become the baseline after 2020. As a result, lighting potential decreases between 2018 and 2023.

Table 6-3: Residential Sector Technical Potential Demand Savings

Summer Peak Demand		
	2018	2023
Summer	MW	MW
Total	4,274	4,138
% of Peak	*42.7%*	*40.5%*

Economic Potential

Economic potential is a subset of technical potential, which only accounts for measures that are cost-effective. This analysis includes two estimates of economic potential. One cost-effectiveness screen is based on the UCT and a second economic potential scenario was screened using the TRC Test. In both scenarios, the utility incentive was assumed to be equal to 50% of the measure incremental cost. The UCT was used for this study because it is mandated in Michigan to be the primary cost-effectiveness test used when considering energy efficiency programs. Because the TRC includes participant costs, it goes beyond utility resource acquisition and looks at the measure/program from a more broad perspective. 79% of all measures that were included in the electric potential analysis passed the UCT and 68% of all measures passed the TRC Test.

Table 6-4 indicates that the economic potential based on the UCT screen is nearly 14.0 million MWh during the 5 year period from 2014 to 2018, and the economic potential more than 12.1 million MWh during the 10 year period from 2014 to 2023. This represents 41.3% and 35.2% of residential sales across the respective 5-year and 10-year timeframes. Similar to the technical potential scenario, lighting represents the greatest contributor to the potential at 43-33% of savings, while the HVAC Equipment, appliances, electronics, and water heating end uses each contribute between 9-20% of the savings. Table 6-5 shows the demand savings potential in 2018 and 2023. The five and ten year summer peak demand savings potential is 3,895 MW and 3,758 MW, respectively, which is 38.9% and 36.7% of the peak forecast.

Table 6-4: Residential Sector Economic Potential (UCT) Energy Savings by End Use

End Use	2018 Energy (MWh)	% of 2018 Savings	2023 Energy (MWh)	% of 2023 Savings
Appliances	1,786,674	13%	1,796,237	15%
Electronics	1,287,615	9%	1,325,226	11%
Lighting	6,049,085	43%	4,043,252	33%
Water Heating	1,346,481	10%	1,390,609	11%
Other	178,956	1%	182,695	2%
HVAC (Envelope)	585,197	4%	597,812	5%
HVAC (Equipment)	2,306,799	17%	2,373,890	20%
Behavioral Programs	427,140	3%	436,525	4%
Total	13,967,946	100%	12,146,247	100%
% of Annual Sales Forecast	*41.3%*		*35.2%*	

Table 6-5: Residential Sector Economic Potential (UCT) Demand Savings

Summer Peak Demand		
	2018	2023
Summary	MW	MW
Total	3,895	3,758
% of Peak	*38.9%*	*36.7%*

Table 6-6 demonstrates that the economic potential based on the TRC screen is lower than the economic potential based on the UCT screen. In 2023, economic potential based on the TRC cost-effectiveness screening is approximately 500,000 MWh lower than the economic potential based on the UCT. The biggest decline in economic potential between the two screens occurred in the HVAC (Equipment) end-use where measure costs are high and incentive amounts can significantly impact cost-effectiveness.

Table 6-6: Residential Sector Economic Potential (TRC) Energy Savings by End Use

End Use	2018 Energy (MWh)	% of 2018 Savings	2023 Energy (MWh)	% of 2023 Savings
Appliances	1,786,674	13%	1,796,237	15%
Electronics	1,287,615	10%	1,325,226	11%
Lighting	5,944,376	44%	3,938,543	34%
Water Heating	1,346,481	10%	1,390,609	12%
Other	178,956	1%	182,695	2%
HVAC (Envelope)	502,389	4%	511,252	4%
HVAC (Equipment)	2,021,744	15%	2,092,466	18%
Behavioral Programs	398,228	3%	406,978	3%
Total	13,466,463	100%	11,644,006	100%
% of Annual Sales Forecast	*39.8%*		*33.7%*	

Table 6-7: Residential Sector Economic Potential (TRC) Demand Savings

Summer Peak Demand		
	2018	2023
Summary	MW	MW
Total	4,106	3,980
% of Peak	*41.0%*	*38.9%*

6.1.1 Achievable Electric Potential Savings in the Residential Sector

Achievable potential is a refinement of economic potential that takes into account the estimated market adoption of energy efficiency measures based on the incentive level and measure payback, the natural replacement cycle of equipment, and the capabilities of programs and administrators to ramp up program activity over time. Achievable potential also takes into account the non-measure costs of delivering programs (for administration, marketing, monitoring and evaluation, etc.). For purposes of this analysis, administrative costs were assumed to be equivalent to 20% of incremental measures costs.

This is based on a published review of typical program administrator costs of several utility energy efficiency programs nationwide.[36]

This study estimated achievable potential for three scenarios. The Achievable UCT Scenario determines the achievable potential of all measures that passed the UCT economic screening assuming incentives equal to 50% of the measure cost.[37] The second scenario, Achievable TRC, also assumes incentives set at 50% of the measure incremental cost, but only includes measures that passed the TRC Test economic screening. The third scenario, Constrained UCT, assumes a spending cap equal to 2% of utility revenues, thereby limiting utilities from reaching the ultimate potential estimated in the Achievable UCT scenario.

6.1.1.1 Achievable UCT vs. Achievable TRC

Tables 6-8 through Table 6-11 show the estimated savings for the Achievable UCT and Achievable TRC scenarios over 5 and 10 year time horizons. As noted above, both scenarios assume an incentive level approximately equal to 50% of the incremental measure cost and include an estimate 10-year market adoption rates based on incentive levels and equipment replacement cycles. However, because more measures pass the UCT relative to the TRC Test, the Achievable UCT scenario is able to include additional measures that would result in greater savings potential over the next five and ten years. Overall the Achievable UCT scenario results in an achievable potential that is roughly 125,000 MWh greater, over the next decade, than the achievable TRC scenario.

Table 6-8: Residential Achievable UCT Potential Electric Energy Savings by End Use

END USE	2018 ENERGY (MWH)	% OF 2018 SAVINGS	2023 ENERGY (MWH)	% OF 2023 SAVINGS
Appliances	366,811	10%	673,510	13%
Electronics	749,078	21%	854,883	17%
Lighting	1,386,345	38%	1,493,016	29%
Water Heating	262,683	7%	594,697	12%
Other	43,585	1%	96,303	2%
HVAC (Envelope)	196,173	5%	395,204	8%
HVAC (Equipment)	344,252	10%	679,549	13%
Behavioral Programs	273,467	8%	283,672	6%
Total	**3,622,394**	100%	**5,070,834**	**100%**
% of Annual Sales Forecast	*10.7%*		*14.7%*	

Table 6-9: Residential Achievable UCT Potential Demand Savings

SUMMER PEAK DEMAND		
	2018	**2023**
Summary	**MW**	**MW**
Total	**839**	**1,338**
% of Peak	*8.4%*	*13.1%*

[36] PacifiCorp Assessment of Long-Term, System-Wide Potential for Demand-Side and Other Supplemental Resources. Volume II. Prepared by Cadmus. March 2013. Appendix B-4.

[37] Traditional low income measures associated with Michigan's Weatherization Assistance Program were evaluated using 100% incentives across all three achievable potential scenarios. All other measures were evaluated at the 50% incentive level.

Table 6-10: Residential Achievable TRC Potential Electric Energy Savings by End Use

END USE	2018 ENERGY (MWH)	% OF 2018 SAVINGS	2023 ENERGY (MWH)	% OF 2023 SAVINGS
Appliances	366,811	10%	673,510	14%
Electronics	749,078	21%	854,883	17%
Lighting	1,353,255	38%	1,440,074	29%
Water Heating	262,683	7%	594,697	12%
Other	43,585	1%	96,303	2%
HVAC (Envelope)	170,658	5%	344,028	7%
HVAC (Equipment)	339,401	10%	670,349	14%
Behavioral Programs	264,123	7%	273,098	6%
Total	**3,549,596**	**100%**	**4,946,942**	**100%**
% of Annual Sales Forecast	*10.5%*		*14.3%*	

Table 6-11: Residential Achievable TRC Potential Demand Savings

SUMMER PEAK DEMAND		
	2018	**2023**
Summary	**MW**	**MW**
Total	**892**	**1,447**
% of Peak	*8.9%*	*14.1%*

The 5-year and 10-year Achievable UCT potential savings estimates are approximately 3.62 million MWh and 5.07 million MWh. This equates to 10.7% and 14.7% of sector sales in 2018 and 2023. By comparison, the respective 5-year and 10-year Achievable TRC potential savings estimates are approximately 3.55 million MWh and 4.95 million MWh. This equates to 10.5% and 14.7% of sector sales in 2018 and 2023. The five and ten year demand savings estimates in the Achievable UCT and Achievable TRC scenarios are depicted in Tables 6-9 and 6-11, respectively.

6.1.1.1 Achievable UCT vs. Constrained UCT

Although the Achievable UCT assumes incentives are set and capped at 50% of the incremental measure cost, and that measures are typically replaced at the end of their useful life, the Achievable UCT scenario also assumes no DSM spending cap to reach all potential participants. In the constrained UCT scenario, the analysis assumes a spending cap roughly equal to 2% of Michigan utility revenue.

Table 6-12 shows the estimated savings for the Constrained UCT scenario over 5 and 10 year time horizon. The 5-year and 10-year Achievable UCT potential savings estimates are approximately 1.5 million MWh and 2.04 million MWh. This equates to 4.3% and 5.9% of sector sales in 2018 and 2023. The five and ten year demand savings estimates in the Constrained UCT scenario are depicted in Table 6-13.

Table 6-12: Residential Constrained Achievable Savings Potential Energy Savings by End Use

END USE	2018 ENERGY (MWH)	% OF 2018 SAVINGS	2023 ENERGY (MWH)	% OF 2023 SAVINGS
End Use	**Energy (MWh)**	**Savings**	**Energy (MWh)**	**Savings**
Appliances	148,073	10%	270,375	13.2%

END USE	2018 ENERGY (MWH)	% OF 2018 SAVINGS	2023 ENERGY (MWH)	% OF 2023 SAVINGS
Electronics	302,513	21%	344,280	16.8%
Lighting	561,760	38%	600,765	29.4%
Water Heating	106,457	7%	240,207	11.7%
Other	17,662	1%	38,902	1.9%
HVAC (Envelope)	79,846	5%	160,036	7.8%
HVAC (Equipment)	139,962	10%	274,607	13.4%
Behavioral Programs	108,763	7%	115,389	5.6%
Total	**1,465,036**	**100%**	**2,044,561**	**100.0%**
% of Annual Sales Forecast	*4.3%*		*5.9%*	

Table 6-13: Residential Constrained Achievable Potential Demand Savings

	SUMMER PEAK DEMAND	
	2018	**2023**
Summary	**MW**	**MW**
Total	**340**	**540**
% of Peak	*3.4%*	*5.3%*

Figure 6-2 shows the percentage of electric savings by each end use for the Constrained UCT scenario. The lighting end use shows the largest potential for savings with 29.4% of total electric savings, followed by the appliances and HVAC Equipment end uses at 16.8% and 13.4%, respectively.

Figure 6-2: Residential Sector 2023 Constrained UCT Electric Potential Savings, by End Use

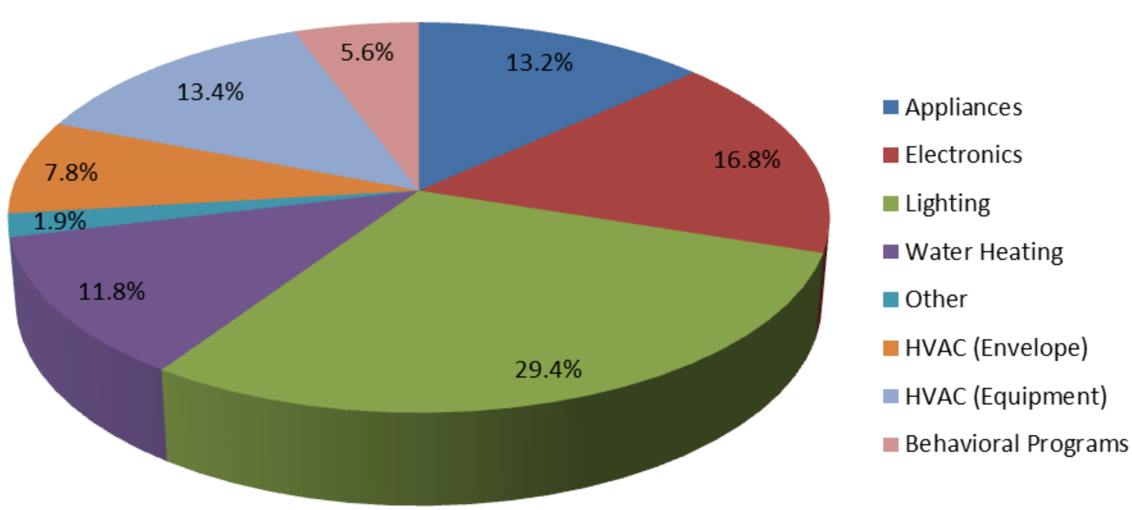
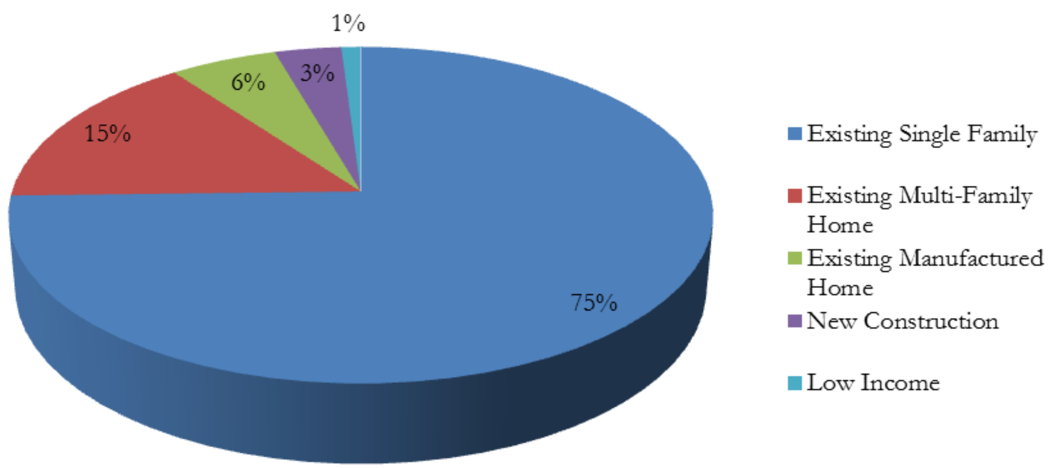


Figure 6-3 shows the breakdown of estimated savings in 2023 by housing type, low-income designation and new construction measures, for the Achievable UCT potential scenario. The savings are largely coming from existing/turnover measures, meaning energy efficient equipment is installed in replacement of existing equipment that has failed. The existing single-family housing and existing multi-family housing types lead the way with 75% of savings and 15% savings, respectively, followed by and 6%

coming from existing manufactured homes. New construction measures account for 3% of total savings and low-income measures account for 1% of total savings. The low-income measures represent only those measures typically included in the Michigan Weatherization Assistance Program to low-income households, and do not represent the combined "low-income potential" in Michigan. There is also low-income potential that is subsumed by the other 99% of the savings associated with the "non-low-income" measures. For example, low income households could realize additional LED lighting and/or behavioral program energy efficiency savings, even though they may not be offered under the traditional umbrella of low-income programs.

Figure 6-3: Residential Constrained Achievable Savings in 2023, by Housing Type, Low-Income Designation and New Construction Measures



6.1.2 Annual Achievable Electric Savings Potential

Table 6-14, Table 6-15 and Table 6-16 shows cumulative annual energy savings (MWh) for all three achievable potential scenarios for each year across the 10-year time horizon for the study, broken out by end use. The year by year associated incentive and administrative costs to achieve these savings are shown later, in Section 6.3. Table 6-17, Table 6-18 and Table 6-19 shows cumulative annual demand (MW) savings for all three achievable potential scenarios for each year across the 10-year time horizon for the study, broken out by end use. The year by year associated incentive and administrative costs to achieve these savings are shown later, in Section 6.3.

Table 6-14: Cumulative Annual Residential Energy Savings in the Achievable UCT Potential Scenario, by End Use for Michigan

END USE	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Appliances	42,168	121,659	202,452	284,548	366,811	449,136	531,497	613,886	661,226	673,510
Electronics	122,694	286,807	451,582	616,766	749,078	830,288	849,138	851,396	853,258	854,883
Lighting	216,439	517,636	810,134	1,098,793	1,386,345	1,668,918	1,944,916	1,247,934	1,411,284	1,493,016
Water Heating	41,463	89,732	142,629	200,126	262,683	329,925	396,279	462,138	528,285	594,697
Other	6,869	14,716	23,561	33,393	43,585	54,095	64,621	75,160	85,721	96,303
HVAC (Envelope)	38,831	77,884	117,126	156,545	196,173	235,906	275,673	315,469	355,316	395,204
HVAC (Equipment)	64,568	131,910	201,006	272,172	344,252	412,858	481,800	551,056	620,301	679,549
Behavioral Programs	97,238	192,172	225,558	254,177	273,467	283,188	283,367	283,463	283,567	283,672
Total	**630,268**	**1,432,515**	**2,174,047**	**2,916,521**	**3,622,394**	**4,264,314**	**4,827,291**	**4,400,502**	**4,798,958**	**5,070,834**
% of Annual Forecast Sales	*1.9%*	*4.2%*	*6.4%*	*8.6%*	*10.7%*	*12.6%*	*14.2%*	*12.9%*	*14.0%*	*14.7%*

Table 6-15: Cumulative Annual Residential Energy Savings in the Achievable TRC Potential Scenario, by End Use for Michigan

END USE	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Appliances	42,168	121,659	202,452	284,548	366,811	449,136	531,497	613,886	661,226	673,510
Electronics	122,694	286,807	451,582	616,766	749,078	830,288	849,138	851,396	853,258	854,883
Lighting	209,821	504,401	790,281	1,072,322	1,353,255	1,629,211	1,898,592	1,194,991	1,358,341	1,440,074
Water Heating	41,463	89,732	142,629	200,126	262,683	329,925	396,279	462,138	528,285	594,697
Other	6,869	14,716	23,561	33,393	43,585	54,095	64,621	75,160	85,721	96,303
HVAC (Envelope)	33,749	67,712	101,852	136,158	170,658	205,263	239,901	274,566	309,277	344,028
HVAC (Equipment)	62,694	128,578	196,755	267,562	339,401	407,578	475,809	544,059	612,183	670,349
Behavioral Programs	98,489	193,009	222,067	247,183	264,123	272,657	272,818	272,905	273,001	273,098
Total	**617,947**	**1,406,612**	**2,131,178**	**2,858,058**	**3,549,596**	**4,178,152**	**4,728,653**	**4,289,102**	**4,681,294**	**4,946,942**
% of Annual Forecast Sales	*1.8%*	*4.2%*	*6.3%*	*8.5%*	*10.5%*	*12.3%*	*13.9%*	*12.5%*	*13.6%*	*14.3%*

Table 6-16: Cumulative Annual Residential Energy Savings in the Constrained UCT Potential Scenario, by End Use for Michigan

END USE	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Appliances	18,519	50,537	82,767	115,359	148,073	180,880	213,908	247,006	264,976	270,375
Electronics	53,883	119,986	185,719	251,295	302,513	333,331	338,776	339,966	341,858	344,280
Lighting	95,053	216,372	332,853	447,415	561,760	674,378	785,076	503,705	569,614	600,765
Water Heating	18,209	37,651	58,753	81,579	106,457	133,253	159,820	186,276	213,074	240,207
Other	3,017	6,177	9,706	13,609	17,662	21,851	26,071	30,305	34,582	38,902
HVAC (Envelope)	17,053	32,784	48,438	64,087	79,846	95,680	111,627	127,614	143,751	160,036
HVAC (Equipment)	28,356	55,481	83,045	111,297	139,962	167,136	194,776	222,610	250,681	274,607
Behavioral Programs	42,704	77,924	90,646	101,108	108,763	112,752	113,383	113,707	114,526	115,389
Total	**276,794**	**596,912**	**891,927**	**1,185,749**	**1,465,036**	**1,719,262**	**1,943,438**	**1,771,191**	**1,933,063**	**2,044,561**
% of Annual Forecast Sales	*0.8%*	*1.8%*	*2.6%*	*3.5%*	*4.3%*	*5.1%*	*5.7%*	*5.2%*	*5.6%*	*5.9%*

Table 6-17: Cumulative Annual Residential Demand Savings in the Achievable UCT Potential Scenario, by End Use for Michigan

END USE	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Appliances	6	17	28	39	51	63	74	86	98	98
Electronics	23	52	82	111	139	158	163	164	164	164
Lighting	25	60	94	128	162	194	227	135	161	161
Water Heating	6	13	21	29	39	48	57	64	80	80
Other	4	9	15	21	27	34	41	47	61	61
HVAC (Envelope)	32	65	97	130	163	196	228	261	327	327
HVAC (Equipment)	42	84	128	172	217	255	292	329	403	403
Behavioral Programs	16	30	35	39	41	43	43	43	43	43
Total	**154**	**331**	**499**	**670**	**839**	**991**	**1,124**	**1,129**	**1,338**	**1,338**
% of Annual Forecast Sales	*1.5%*	*3.3%*	*5.0%*	*6.7%*	*8.4%*	*9.9%*	*11.1%*	*11.1%*	*13.1%*	*13.1%*

Table 6-18: Cumulative Annual Residential Demand Savings in the Achievable TRC Potential Scenario, by End Use for Michigan

END USE	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Appliances	6	17	28	39	51	63	74	86	94	98
Electronics	23	52	82	111	139	158	163	164	164	164
Lighting	25	60	94	128	162	194	227	135	153	161
Water Heating	6	13	21	29	39	48	57	64	72	80
Other	4	9	15	21	27	34	41	47	54	61
HVAC (Envelope)	30	60	90	120	151	181	211	242	272	303
HVAC (Equipment)	54	109	166	225	284	335	386	437	487	538
Behavioral Programs	16	31	35	39	41	42	42	42	42	42
Total	**165**	**352**	**531**	**712**	**892**	**1,056**	**1,201**	**1,217**	**1,339**	**1,447**
% of Annual Forecast Sales	*1.6%*	*3.5%*	*5.3%*	*7.1%*	*8.9%*	*10.5%*	*11.9%*	*12.0%*	*13.1%*	*14.1%*

Table 6-19: Cumulative Annual Residential Demand Savings in the Constrained UCT Potential Scenario, by End Use for Michigan

END USE	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Appliances	3	7	11	16	21	25	30	34	38	40
Electronics	10	22	34	45	56	64	65	65	66	66
Lighting	11	25	39	52	65	79	91	55	62	65
Water Heating	3	6	9	12	16	19	23	26	29	32
Other	2	4	6	9	11	14	16	19	22	24
HVAC (Envelope)	14	27	40	53	66	79	92	106	119	132
HVAC (Equipment)	18	35	53	70	88	103	118	133	148	163
Behavioral Programs	7	12	14	15	16	17	17	17	17	17
Total	**68**	**138**	**206**	**273**	**340**	**400**	**453**	**455**	**500**	**540**
% of Annual Forecast Sales	*0.7%*	*1.4%*	*2.0%*	*2.7%*	*3.4%*	*4.0%*	*4.5%*	*4.5%*	*4.9%*	*5.3%*

6.1.3 Residential Electric Savings Summary by Measure Group

Table 6-20 provides an end-use breakdown of the residential electric savings potential estimates for technical and economic potential, and each of the three achievable potential scenarios. The table indicates how the savings potential decreases systematically from the technical potential scenario to the Constrained UCT potential scenario as additional limiting factors such as cost-effectiveness requirements and anticipated market adoption at given funding levels are introduced.

Table 6-20: Breakdown of Residential Cumulative Annual Electric Savings Potential for Technical, Economic and Achievable Potential, by End Use for Michigan

End Use	Technical Potential (MWh)	Economic Potential -UCT- (MWh)	Economic Potential -TRC- (MWh)	Achievable Potential -UCT- (MWh)	Achievable Potential -TRC- (MWh)	Constrained Achievable –UCT-(MWh)
Appliances						
ENERGY STAR Refrigerators	177,216	177,216	177,216	35,527	35,527	14,321
ENERGY STAR Freezers	68,256	68,256	68,256	20,772	20,772	8,377
ENERGY STAR Clothes Washers	36,910	0	0	0	0	0
ENERGY STAR Dishwashers	33,314	0	0	0	0	0
ENERGY STAR Dehumidifiers	115,083	115,083	115,083	55,602	55,602	22,468
Heat Pump Dryer	64,594	0	0	0	0	0
2nd Refrigerator Turn-In	1,338,562	1,338,562	1,338,562	523,648	523,648	209,987
2nd Freezer Turn-In	94,465	94,465	94,465	36,956	36,956	14,820
2nd Dehumidifier Turn-In	2,654	2,654	2,654	1,004	1,004	403
Electronics						
Controlled Power Strips	99,152	0	0	0	0	0
Efficient Set Top Box	184,053	184,053	184,053	114,535	114,535	46,146
Efficient Desktop PCs	325,626	325,626	325,626	178,022	178,022	71,920
Efficient Laptop PCs	49,906	81,304	81,304	35,185	35,185	14,215
Efficient Televisions	617,351	617,351	617,351	447,761	447,761	180,017
Efficient Computer Monitors	116,891	116,891	116,891	79,380	79,380	31,982
Lighting						
Specialty CFL Bulbs	1,697,182	1,697,182	1,697,182	632,114	632,114	253,403
Standard Screw-In CFL Bulbs	74,338	74,338	74,338	33,798	33,798	13,499
LED Screw-In Bulbs	505,347	505,347	505,347	261,450	261,450	105,624
Specialty LED Bulbs	810,552	810,552	810,552	136,979	136,979	55,304
Exterior Lighting - CFL Bulbs	0	0	0	0	0	0
Exterior Lighting - LED Bulbs	358,353	358,353	358,353	210,558	210,558	84,985
Efficient Torchiere Floor Lamps	421,159	421,159	421,159	117,308	117,308	47,380
Efficient Fluorescent Tube	181,345	0	0	0	0	0

END USE	TECHNICAL POTENTIAL (MWH)	ECONOMIC POTENTIAL -UCT- (MWH)	ECONOMIC POTENTIAL -TRC- (MWH)	ACHIEVABLE POTENTIAL -UCT- (MWH)	ACHIEVABLE POTENTIAL -TRC- (MWH)	CONSTRAINED ACHIEVABLE –UCT-(MWH)
Lighting						
LED Night Lights	27,001	27,001	27,001	15,178	15,178	6,124
Occupancy Sensors	212,086	0	0	0	0	0
Holiday Lights	97,240	0	0	0	0	0
Multifamily Common Areas	182,976	149,320	44,611	85,632	32,689	34,445
Water Heating						
Heat Pump Water Heater	575,030	1,150,060	1,150,060	415,300	415,300	167,673
Solar Water Heating	450,528	0	0	0	0	0
Gravity Film Heat Exchanger	127,171	0	0	0	0	0
Pipe Wrap	15,019	15,019	15,019	10,714	10,714	0
Low Flow Showerheads	93,813	93,813	93,813	71,455	71,455	4,307
Shower Starters (with LF Showerheads)	25,983	25,983	25,983	17,834	17,834	28,899
Low Flow Faucet Aerators	105,649	105,733	105,733	79,394	79,394	7,212
Other						
Efficient Pool Pump Motors	182,695	182,695	182,695	96,303	96,303	38,902
HVAC (Envelope)						
Ceiling/Attic Insulation	87,119	68,141	60,096	53,344	47,041	21,604
Wall Insulation	63,858	16,044	7,950	9,892	5,844	4,004
Floor Insulation	(33,946)	437	25	101	6	41
Basement Wall Insulation	(7,331)	7,049	1,535	4,932	1,087	1,997
Crawlspace Wall Insulation	(1,220)	4,146	418	1,220	102	494
Air Sealing	50,656	35,864	37,192	26,851	27,996	10,867
Duct Sealing	16,540	17,273	14,747	12,450	10,331	5,039
Duct Insulation	7,465	8,203	8,757	5,798	6,235	2,344
Duct Location (move into conditioned space)	30,081	40,917	17,712	16,967	5,934	6,867
ENERGY STAR Windows	263,771	270,538	306,702	177,032	201,379	71,698
Window Film	122,980	118,769	49,196	78,143	32,367	31,648
ENERGY STAR Doors	65,374	0	0	0	0	0
Cool Roof	95,434	462	462	68	68	27
Low Income Weatherization Package	155,032	11,385	7,876	8,998	6,230	3,644
Steam Pipe Insulation	(1,417)	(1,417)	(1,417)	(591)	(591)	(238)
HVAC (Equipment)						
ENERGY STAR Air Source Heat Pumps	38,547	40,843	40,595	9,444	9,449	3,820

END USE	TECHNICAL POTENTIAL (MWH)	ECONOMIC POTENTIAL -UCT- (MWH)	ECONOMIC POTENTIAL -TRC- (MWH)	ACHIEVABLE POTENTIAL -UCT- (MWH)	ACHIEVABLE POTENTIAL -TRC- (MWH)	CONSTRAINED ACHIEVABLE –UCT-(MWH)
ENERGY STAR Dual Fuel Heat Pumps	29,542	29,542	30,259	7,348	7,599	2,971
Geothermal Heat Pumps	16,061	0	0	0	0	0
ENERGY STAR Central Air Conditioners	1,045,448	1,045,448	1,050,054	203,190	204,230	82,278
ENERGY STAR Room Air Conditioners	60,860	60,860	60,860	11,537	11,537	4,664
Room Air Conditioner Recycling	13,412	13,412	13,412	4,937	4,937	1,980
Central AC Tune-Up	82,810	82,810	81,905	21,261	24,153	8,566
Ductless Mini-Split Systems	215,552	15,740	17,044	4,166	4,533	1,684
Thermostat setback strategies	230,904	210,221	210,221	109,911	109,911	44,099
Whole House Fans	264,362	0	0	0	0	0
Efficient Chillers	44,659	44,659	44,659	11,791	11,791	4,730
Chiller Controls	679	679	679	364	364	147
Efficient Furnaces	775,125	762,124	0	249,211	0	100,908
Efficient Furnace Fans	112,094	136,841	614,917	67,086	303,764	27,139
Efficient Boilers	(49,097)	(67,818)	(69,788)	(19,940)	(20,744)	(8,073)
Boiler Controls	(1,452)	(1,472)	(2,351)	(758)	(1,174)	(307)
Behavioral Programs						
Direct Feedback (In-Home Energy Display)	229,932	229,932	191,825	129,116	112,531	52,290
Indirect Feedback (Monthly Energy Use Reports)	206,593	206,593	215,153	154,556	160,568	63,099
Total	**13,697,929**	**12,146,247**	**11,644,006**	**5,070,834**	**4,946,942**	**2,044,561**
% of Annual 2022 Sales Forecast	*39.7%*	*35.2%*	*33.7%*	*14.7%*	*14.3%*	*5.9%*
Note: Measures in the above Table with "0" achievable potential are ones that did not pass the Economic screening						

Table 6-21 provides a list of the Top 10 residential electric savings measures for the Achievable UCT scenario. The table provides the measures ranked according to the electric savings potential. The column to the far right shows the results of the measure level cost-effectiveness screening test using the UCT to screen the measures. The measures in the table are representative of a group of comparable measures falling under the umbrella of the measure categories provided in the table. This means that there are a range of UCT ratios for measure iterations that fall into a single measure category. For example, "Specialty LED Bulbs" is a measure category which consists of several measure iterations to account for bulb type and wattage and housing type. The table presents an average of the UCT ratios for all measures which are part of the measure categories in the Top 10.

The Top 10 measures combine to yield an estimated 3.3 million MWh savings. This accounts for nearly 65% of the total residential electric savings in the Achievable UCT scenario.

Table 6-21: Top 10 Residential Electric Savings Measures in the Achievable UCT Scenario

MEASURE		2023 ENERGY (MWH)	% OF SECTOR SAVINGS	UCT RATIO
1	Specialty CFL Bulbs	632,114	12.5%	3.78
2	2nd Refrigerator Turn-In	523,648	10.3%	5.56
3	Efficient Televisions	447,761	8.8%	114.97
4	Heat Pump Water Heater	415,300	8.2%	5.43
5	LED Screw-In Bulbs	251,464	5.0%	2.92
6	Efficient Furnaces (Furnace Fans)	249,211	4.9%	21.32
7	Exterior Lighting - LED Bulbs	210,558	4.1%	8.11
8	ENERGY STAR Central Air Conditioners	203,190	4.0%	2.72
9	Efficient Desktop PCs	178,022	3.5%	4.00
10	ENERGY STAR Windows	177,032	3.5%	2.12
Total		3,288,300	64.8%	

6.2 RESIDENTIAL NATURAL GAS POTENTIAL

Natural gas consumption forecasts for the residential, commercial and institutional segments of the Michigan economy indicate that natural gas demand will decrease from nearly 653 million MMBTu in 2014 to 603 million MMBTu in 2023 (representing a compound average annual rate of growth of -0.9%)[38]. The residential sector is expected to decline more rapidly compared to the state as a whole, with a forecasted average annual growth rate for 2014 to 2023 of -1.2%. The residential gas potential calculations are based upon these approximate consumption values and sales forecast figures over the time horizon covered by the study. The potential is calculated for the entire residential sector and includes breakdowns of the potential associated with each end use.

6.2.1 Energy Efficiency Measures Examined

For the residential sector, there were 791 natural gas savings measures included in the potential gas savings analysis[39]. Table 6-22 provides a brief description of the types of measures included for each end use in the residential model. The list of measures was developed based on a review of the MEMD and measures found in other residential potential studies and TRMs in the Midwest. Measure data includes incremental costs, electricity energy and demand savings, gas and water savings, and measure life.

Table 6-22: Measures and Programs Included in the Gas Residential Sector Analysis

END USE TYPE	END USE DESCRIPTION	MEASURES INCLUDED
HVAC Envelope	Building Envelope Upgrades	• Air/duct Sealing • Duct Insulation • Improved Insulation (Wall, Ceiling, and Floor) • Efficient Windows • Window film • ENERGY STAR doors • Cool Roofs • Low Income Weatherization Package

[38] Estimated for statewide sales based on Michigan utility load forecast data and historical sales.
[39] This total represents the number of unique energy efficiency measures and all permutations of these unique measures. For example, there are 15 permutations of the "Setback Thermostat" measure to account for the various housing types, heating/cooling combinations, and construction types.

END USE TYPE	END USE DESCRIPTION	MEASURES INCLUDED
HVAC Equipment	Heating/Cooling/Ventilation Equipment	• Existing Gas Furnace/Boiler Tune-up • Efficient Gas Furnaces • Efficient Gas Boilers • Boiler Controls • Set Back Thermostats
Water Heating	Domestic Hot Water	• Efficient Gas Storage Tank WH • Tankless Gas WH • Low Flow Showerhead/Faucet Aerator • Pipe Wrap • Gravity Film Heat Exchangers
Appliances	High-Efficiency Appliances / Retirement of Inefficient Appliances	• ENERGY STAR Clothes Washers • ENERGY STAR Dishwashers
Behavioral	Consumer Response to Feedback from Utility	• Direct (Real-Time) Feedback • Indirect Feedback

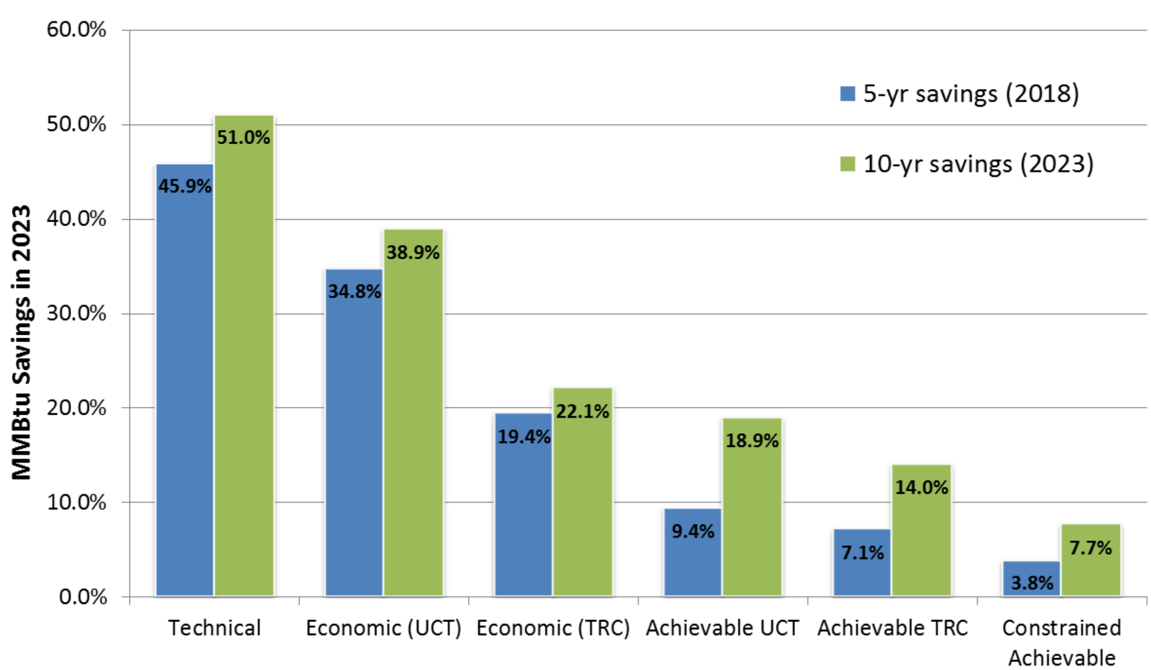
6.2.2 Overview of Residential Natural Gas Energy Efficiency Potential

This section presents estimates for gas technical, economic, and achievable potential for the residential sector. Each of the tables in the technical, economic and achievable sections present the respective potential for efficiency savings expressed as cumulative annual energy savings (MMBtu), percentage of savings by end use, and savings as a percentage of forecast sales. Data is provided on a 5-year and 10-year time horizon for Michigan.

SUMMARY OF FINDINGS

Figure 6-4 illustrates the estimated savings potential for each of the scenarios included in this study.

Figure 6-4: Summary of Residential Energy Efficiency Potential as a % of 2018 and 2023 Sales Forecasts



The potential estimates are expressed as cumulative 5-year and 10-year savings, as percentages of the respective 2018 and 2023 sector sales. The technical potential is 45.9% in 2018 and 51.0% in 2023. The

5-year and 10-year economic potential is 34.8% and 38.9% based on the Utility Cost Test (UCT) screen, assuming an incentive level equal to 50% of the measure cost. Based on a measure-level screen using the TRC Test, the economic potential is 19.4% in 2018 and 22.1% in 2023. The significant drop from technical between the two economic potential scenarios indicates that most measures are cost-effective when screening based on the UCT, but fall below the threshold of cost-effectiveness when screening based on the TRC Test.

The 5-year and 10-year achievable potential savings are: 9.4% and 18.9% for the Achievable UCT scenario; 7.1% and 14.0% for the Achievable TRC scenario; and 3.8% and 7.7% for the Constrained Achievable scenario. The Achievable UCT scenario assumes 50% incentives and includes measures that passed the UCT Test. The Achievable TRC scenario also assumes 50% incentives but includes only measures that passed the cost-effectiveness screen based on the TRC Test. Last, the Constrained Achievable scenario is a subset of Achievable UCT scenario, assuming a spending cap on DSM approximately equal to 2% of future annual residential revenue.

TECHNICAL POTENTIAL

Technical potential represents the quantification of savings that can be realized if all technologically available energy-efficiency measures are immediately adopted in all feasible instances, regardless of cost. Table 6-23 shows that it is technically feasible to save about 136.7 million MMBtu in the residential sector between 2014 and 2018 and approximately 143.3 million MMBtu during the 10 year period from 2014 to 2023 across Michigan, representing 45.9% of 2018 residential sales, and 51.0% of 2023 residential sales. The HVAC Envelope end use represents the greatest contributor to the potential at 44% of 10-yr savings, while the HVAC Equipment end use contributes 40% of the 10-yr savings, and the Water Heating end use contributes 19% of the 10-yr savings. Conversely, the lighting end use yields a 5% gain in consumption. While there is significant potential for electric savings in the lighting end use, this potential would produce a negative impact on natural gas potential, due to increased heating requirements associated with efficiency lighting.[40] Other measures such as efficient air conditioners and efficient electric water heaters also increase heating requirements due to the minor reductions in heat losses associated with these measures.

Table 6-23: Residential Sector Technical Potential MMBtu Savings by End Use

END USE	2018 SAVINGS (MMBTU)	% OF 2018 SAVINGS	2023 SAVINGS (MMBTU)	% OF 2023 SAVINGS
Appliances	1,338,540	1%	1,370,972	1%
Electronics	0	0%	0	0%
Lighting	-10,132,368	-7%	-7,413,995	-5%
Water Heating	25,653,133	19%	26,569,703	19%
Other	0	0%	0	0%
HVAC (Envelope)	61,077,744	45%	62,401,101	44%
HVAC (Equipment)	55,510,229	41%	57,012,809	40%
Behavioral Programs	3,259,386	2%	3,331,000	2%
Total	**136,706,666**	**100%**	**143,271,591**	**100%**
% of Annual Sales Forecast	*45.9%*		*51.0%*	

[40] High efficiency lighting reduces the amount of waste heat that is released during hours of lighting operation. The reduction in waste heat places a greater burden on heating equipment (electric and gas) to meet the winter heating load requirements.

ECONOMIC POTENTIAL

Economic potential is a subset of technical potential, which only accounts for measures that are cost-effective. This analysis includes two estimates of economic potential. One cost-effectiveness screen is based on the UCT and a second economic potential scenario was screened using the TRC Test. In both scenarios, the utility incentive was assumed to be equal to 50% of the measure incremental cost. The UCT was used for this study because it is mandated in Michigan to be the primary cost-effectiveness test used when considering energy efficiency programs. Because the TRC includes participant costs, it goes beyond utility resource acquisition and looks at the measure/program from a more broad perspective. 77% of all measures that were included in the electric potential analysis passed the UCT and 62% of all measures passed the TRC Test.

Table 6-24 indicates that the economic potential based on the UCT screen is nearly 103.4 million MMBtu during the 5 year period from 2014 to 2018. The economic potential increases to nearly 109.3 million MMBtu during the 10 year period from 2014 to 2023. This represents 34.8% and 38.9% of residential sales across the respective 2018 and 2023 sales. The HVAC Equipment end use represents the greatest contributor to the potential at 52% of the 10-yr savings, while the HVAC Envelope and Water Heating end use contributes 31% and 20% of the 10-yr savings.

Table 6-24: Statewide Residential Sector Economic Potential (UCT) MMBtu Savings by End Use

END USE	2018 SAVINGS (MMBTU)	% OF 2018 SAVINGS	2023 SAVINGS (MMBTU)	% OF 2023 SAVINGS
Appliances	0	0%	0	0%
Electronics	0	0%	0	0%
Lighting	-8,860,565	-9%	-6,116,785	-6%
Water Heating	21,196,030	20%	21,902,671	20%
Other	0	0%	0	0%
HVAC (Envelope)	32,652,145	32%	33,635,009	31%
HVAC (Equipment)	55,340,011	53%	56,546,757	52%
Behavioral Programs	3,259,386	3%	3,331,000	3%
Total	**103,587,007**	**100%**	**109,298,652**	**100%**
% of Annual Sales Forecast	*34.8%*		*38.9%*	

Table 6-25 demonstrates that the economic potential based on the TRC screen is lower than the economic potential based on the UCT screen. In 2023, economic potential based on the TRC cost-effectiveness screening is approximately 47 million MMBtu lower than the economic potential based on the UCT. The biggest decline in economic potential between the two screens occurred in the HVAC (Equipment) end-use where measure costs are high and incentive amounts can significantly impact cost-effectiveness.

Table 6-25: Statewide Residential Sector Economic Potential (TRC) MMBtu Savings by End Use

END USE	2018 SAVINGS (MMBTU)	% OF 2018 SAVINGS	2023 SAVINGS (MMBTU)	% OF 2023 SAVINGS
Appliances	0	0%	0	0%
Electronics	0	0%	0	0%
Lighting	-8,684,361	-15%	-5,940,582	-10%

END USE	2018 SAVINGS (MMBTU)	% OF 2018 SAVINGS	2023 SAVINGS (MMBTU)	% OF 2023 SAVINGS
Water Heating	8,100,414	14%	8,425,883	14%
Other	0	0%	0	0%
HVAC (Envelope)	28,284,493	49%	28,933,758	47%
HVAC (Equipment)	27,188,515	47%	27,609,723	44%
Behavioral Programs	2,996,531	5%	3,062,371	5%
Total	**57,885,592**	**100%**	**62,091,152**	**100%**
% of Annual Sales Forecast	*19.4%*		*22.1%*	

6.2.3 Achievable Natural Gas Potential Savings in the Residential Sector

Achievable potential is a refinement of economic potential that takes into account the estimated market adoption of energy efficiency measures based on the incentive level and measure payback, the natural replacement cycle of equipment, and the capabilities of programs and administrators to ramp up program activity over time. Achievable potential also takes into account the non-measure costs of delivering programs (for administration, marketing, monitoring and evaluation, etc.). As noted in Section 6.1.3, administrative costs were assumed to be equivalent to 20% of incremental measures costs.

This study estimated achievable potential for three scenarios. The Achievable UCT Scenario determines the achievable potential of all measures that passed the UCT economic screening assuming incentives equal to 50% of the measure cost. The second scenario, Achievable TRC, also assumes incentives set at 50% of the measure incremental cost, but only includes measures that passed the TRC Test economic screening. The third scenario, Constrained UCT, assumes a spending cap equal to 2% of utility revenues, thereby limiting utilities from reaching the ultimate potential estimated in the Achievable UCT scenario.

6.2.3.1 Achievable UCT vs. Achievable TRC

Tables 6-26 and 6-27 show the estimated savings for the Achievable UCT and Achievable TRC scenarios over 5 and 10 year time horizons. As noted above, both scenarios assume an incentive level approximately equal to 50% of the incremental measure cost and include estimated 10-year market adoption rates based on incentive levels and equipment replacement cycles. However, because more measures pass the UCT relative to the TRC Test, the Achievable UCT scenario is able to include additional measures that would result in greater savings potential over the next five and ten years. Overall the Achievable UCT scenario results in an achievable potential that is 13.8 million MMBTu greater, over the next decade, than the achievable TRC scenario.

Table 6-26: Residential Achievable UCT Natural Gas Potential Savings by End Use

END USE	2018 ENERGY (MMBTU)	% OF 2018 SAVINGS	2023 ENERGY (MMBTU)	% OF 2023 SAVINGS
Appliances	0	0%	0	0%
Electronics	0	0%	0	0%
Lighting	-2,078,125	-7%	-2,129,625	-4%
Water Heating	5,487,630	20%	9,244,933	17%
Other	0	0%	0	0%
HVAC (Envelope)	10,288,230	37%	20,959,241	39%

END USE	2018 ENERGY (MMBTU)	% OF 2018 SAVINGS	2023 ENERGY (MMBTU)	% OF 2023 SAVINGS
HVAC (Equipment)	12,193,400	44%	22,978,405	43%
Behavioral Programs	2,038,931	7%	2,125,751	4%
Total	**27,930,065**	**100%**	**53,178,705**	**100%**
% of Annual Sales Forecast	*9.4%*		*18.9%*	

Table 6-27: Residential Achievable TRC Potential Natural Gas Savings by End Use

END USE	2018 ENERGY (MMBTU)	% OF 2018 SAVINGS	2023 ENERGY (MMBTU)	% OF 2023 SAVINGS
Appliances	0	0%	0	0%
Electronics	0	0%	0	0%
Lighting	-2,022,443	-9%	-2,040,534	-5%
Water Heating	4,218,934	20%	6,659,203	17%
Other	0	0%	0	0%
HVAC (Envelope)	9,276,023	44%	18,911,780	48%
HVAC (Equipment)	7,875,910	37%	13,772,046	35%
Behavioral Programs	1,947,669	9%	2,023,974	5%
Total	**21,296,093**	**100%**	**39,326,470**	**100%**
% of Annual Sales Forecast	*7.1%*		*14.0%*	

The 5-year and 10-year Achievable UCT potential savings estimates are approximately 27.9 million MMBtu and 53.2 million MMBtu. This equates to 9.4% and 18.9% of sector sales in 2018 and 2023. By comparison, the respective 5-year and 10-year Achievable TRC potential savings estimates are approximately 21.3 million MMBtu and 39.3 million MMBtu. This equates to 7.1% and 14.0% of sector sales in 2018 and 2023.

6.2.3.2 Achievable UCT vs. Constrained UCT

Although the Achievable UCT assumes incentives are set and capped at 50% of the incremental measure cost, and that measures are typically replaced at the end of their useful life, the Achievable UCT scenario also assumes no DSM spending cap to reach all potential participants. In the constrained UCT scenario, the analysis assumes a spending cap roughly equal to 2% of Michigan utility revenue.

Table 6-28 shows the estimated savings for the Constrained UCT scenario over 5 and 10 year time horizons. The 5-year and 10-year Achievable UCT potential savings estimates are approximately 11.4 million MMBTu and 21.5 million MMBTu. This equates to 3.8% and 7.7% of sector sales in 2018 and 2023.

Table 6-28: Residential Constrained Achievable Potential Natural Gas Savings by End Use

END USE	2018 ENERGY (MMBTU)	% OF 2018 SAVINGS	2023 ENERGY (MMBTU)	% OF 2023 SAVINGS
Appliances	0	0%	0	0%
Electronics	0	0%	0	0%

END USE	2018 ENERGY (MMBTU)	% OF 2018 SAVINGS	2023 ENERGY (MMBTU)	% OF 2023 SAVINGS
Lighting	-842,158	-7%	-856,494	-4%
Water Heating	2,226,078	20%	3,733,128	17%
Other	0	0%	0	0%
HVAC (Envelope)	4,184,483	37%	8,483,866	39%
HVAC (Equipment)	4,952,718	44%	9,270,666	43%
Behavioral Programs	810,938	7%	864,248	4%
Total	**11,332,060**	**100%**	**21,495,414**	**100%**
% of Annual Sales Forecast	*3.8%*		*7.7%*	

Figure 6-5 shows the estimated 10-year cumulative efficiency savings for the Constrained UCT Achievable potential scenario, broken out by end use across the entire residential sector. The HVAC Equipment end use shows the largest potential for savings at nearly 9.3 million MMBtu, or 43% of total savings. This figure also illustrates the negative impact on natural gas potential, due to increased heating requirements associated with efficiency lighting.

Figure 6-5: Residential Sector 2023 Achievable Potential Savings for the Constrained UCT Scenario, by End Use

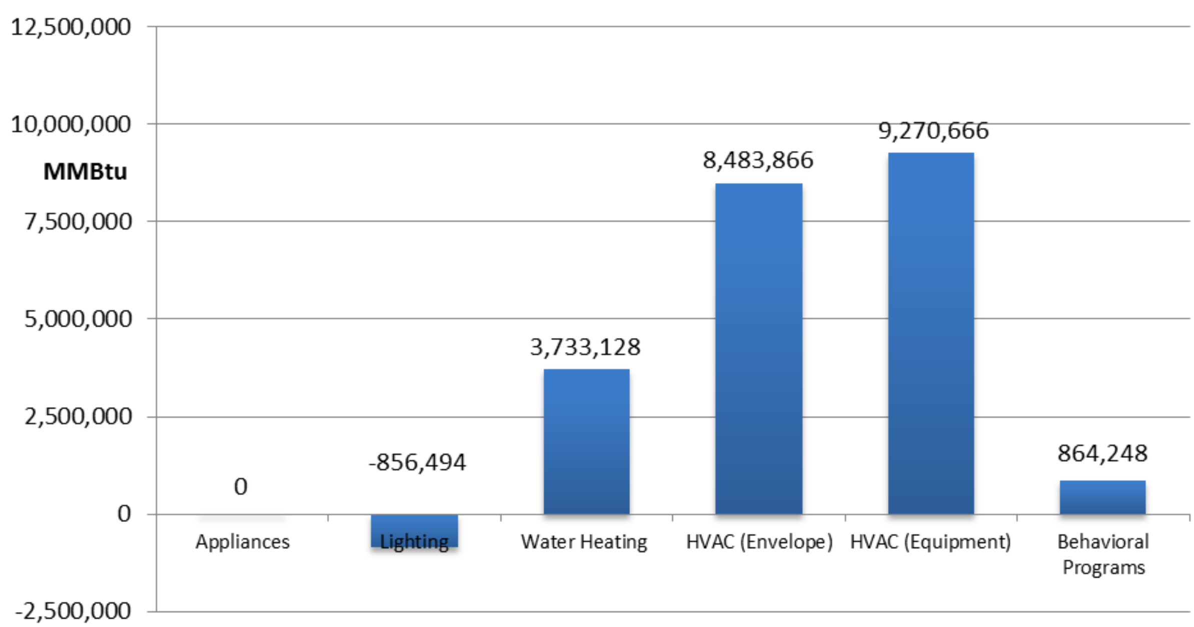
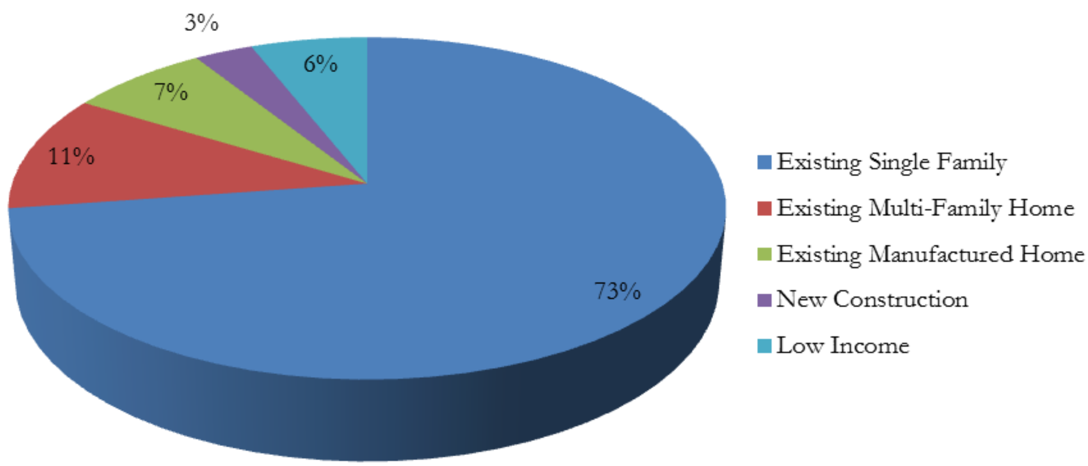


Figure 6-6 shows the breakdown of estimated savings in 2023 by housing type, low-income designation and new construction measures, for the Base Achievable potential scenario. The savings are largely coming from existing/turnover measures, meaning energy efficient equipment is installed in replacement of existing equipment that has failed. The existing single-family housing and existing multi-family housing types lead the way with 73% of savings and 11% savings, respectively, followed by and 7% coming from manufactured. New construction measures account for 3% of total savings and low-income measures account for 6% of total savings. As noted in the electric potential portion of this section, the low-income measures represent only those measures typically included in the Michigan Weatherization Assistance Program to low-income households, and do not represent the combined "low-income potential" in Michigan. There is also low-income potential that is subsumed by the other 93% of the savings associated with the "non-low-income" measures. For example, low income households could realize additional behavioral program energy efficiency savings, even though they may not be offered under the traditional umbrella of low-income programs.

Figure 6-6: Residential Constrained UCT Achievable Savings in 2023, by Housing Type, Low-Income Designation and New Construction Measures



6.2.4 Annual Achievable Natural Gas Savings Potential

Table 6-29, Table 6-30 and Table 6-31 shows cumulative annual energy savings for all three achievable potential scenarios for each year across the 10-year time horizon for the study, broken out by end use. The year by year associated incentive and administrative costs to achieve these savings are shown later, in Section 1.3.

Table 6-29: Cumulative Annual Residential Energy Savings in the Achievable UCT Potential Scenario, by End Use for Michigan

END-USE	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Appliances	0	0	0	0	0	0	0	0	0	0
Electronics	0	0	0	0	0	0	0	0	0	0
Lighting	-327,250	-780,489	-1,218,481	-1,649,639	-2,078,125	-2,498,033	-2,906,848	-1,797,661	-2,031,566	-2,129,625
Water Heating	898,853	2,041,306	3,187,584	4,335,557	5,487,630	6,636,700	7,446,562	8,044,718	8,644,039	9,244,933
Other	0	0	0	0	0	0	0	0	0	0
HVAC (Envelope)	1,967,707	3,987,284	6,053,543	8,164,559	10,288,230	12,416,866	14,548,080	16,681,552	18,818,770	20,959,241
HVAC (Equipment)	2,402,498	4,942,165	7,495,237	9,836,729	12,193,400	14,506,779	16,828,641	19,159,724	21,496,017	22,978,405
Behavioral Programs	671,261	1,345,436	1,630,274	1,874,486	2,038,931	2,121,830	2,123,319	2,124,095	2,124,911	2,125,751
Total	**5,613,070**	**11,535,702**	**17,148,156**	**22,561,693**	**27,930,065**	**33,184,142**	**38,039,753**	**44,212,427**	**49,052,171**	**53,178,705**
% of Annual Forecast Sales	*1.8%*	*3.7%*	*5.6%*	*7.4%*	*9.4%*	*11.3%*	*13.1%*	*15.4%*	*17.3%*	*18.9%*

Table 6-30: Cumulative Annual Residential Energy Savings in the Achievable TRC Potential Scenario, by End Use for Michigan

END-USE	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Appliances	0	0	0	0	0	0	0	0	0	0
Electronics	0	0	0	0	0	0	0	0	0	0
Lighting	-316,113	-758,216	-1,185,072	-1,605,093	-2,022,443	-2,431,214	-2,828,893	-1,708,570	-1,942,475	-2,040,534
Water Heating	651,832	1,544,678	2,437,437	3,327,692	4,218,934	5,106,002	5,653,199	5,988,148	6,323,308	6,659,203
Other	0	0	0	0	0	0	0	0	0	0
HVAC (Envelope)	1,768,472	3,587,495	5,451,406	7,358,198	9,276,023	11,198,197	13,122,719	15,049,208	16,979,017	18,911,780
HVAC (Equipment)	1,589,392	3,322,981	5,064,813	6,472,775	7,875,910	9,223,907	10,572,720	11,922,919	13,275,612	13,772,046
Behavioral Programs	675,726	1,341,107	1,588,993	1,803,290	1,947,669	2,020,431	2,021,757	2,022,455	2,023,207	2,023,974
Total	**4,369,309**	**9,038,046**	**13,357,577**	**17,356,862**	**21,296,093**	**25,117,323**	**28,541,502**	**33,274,160**	**36,658,669**	**39,326,470**
% of Annual Forecast Sales	*1.4%*	*2.9%*	*4.3%*	*5.7%*	*7.1%*	*8.5%*	*9.8%*	*11.6%*	*12.9%*	*14.0%*

Table 6-31: Cumulative Annual Residential Energy Savings in the Constrained UCT Potential Scenario, by End Use for Michigan

END-USE	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Appliances	0	0	0	0	0	0	0	0	0	0
Electronics	0	0	0	0	0	0	0	0	0	0
Lighting	-143,718	-326,278	-500,661	-671,771	-842,158	-1,009,511	-1,173,483	-725,824	-820,140	-856,494
Water Heating	394,748	854,916	1,312,192	1,767,926	2,226,078	2,683,996	2,995,732	3,235,446	3,481,515	3,733,128
Other	0	0	0	0	0	0	0	0	0	0
HVAC (Envelope)	864,155	1,677,619	2,501,897	3,339,949	4,184,483	5,032,763	5,887,408	6,744,497	7,609,997	8,483,866
HVAC (Equipment)	1,055,101	2,078,052	3,096,531	4,016,679	4,952,718	5,872,321	6,804,229	7,741,775	8,689,787	9,270,666
Behavioral Programs	294,797	546,360	656,042	745,878	810,938	844,711	849,338	851,874	857,876	864,248
Total	**2,465,083**	**4,830,669**	**7,066,001**	**9,198,660**	**11,332,060**	**13,424,280**	**15,363,223**	**17,847,768**	**19,819,035**	**21,495,414**
% of Annual Forecast Sales	*0.8%*	*1.6%*	*2.3%*	*3.0%*	*3.8%*	*4.6%*	*5.3%*	*6.2%*	*7.0%*	*7.7%*

6.2.5 Residential Gas Savings Summary by Measure Group

Table 6-32 provides an end-use breakdown of the residential natural gas savings potential estimates for technical and economic potential, and each of the three achievable potential scenarios. The table indicates how the savings potential decreases systematically from the technical potential scenario to the Constrained Achievable potential scenario as additional limiting factors such as cost-effectiveness requirements and anticipated market adoption at given funding levels are introduced.

Table 6-32: Breakdown of Residential Cumulative Annual Gas Savings Potential for Technical, Economic and Achievable Potential, by End Use for Michigan

End Use	Technical Potential (MMBtu)	Economic Potential -UCT- (MMBtu)	Economic Potential -TRC- (MMBtu)	Achievable Potential -UCT- (MMBtu)	Achievable Potential -TRC- (MMBtu)	Constrained Achievable –UCT- (MMBtu)
Appliances						
ENERGY STAR Clothes Washers	1,234,592	0	0	0	0	0
ENERGY STAR Dishwashers	136,380	0	0	0	0	0
Lighting						
Specialty CFL Bulbs	(2,818,389)	(2,818,389)	(2,818,389)	(1,049,706)	(1,049,706)	(420,809)
Standard Screw-In CFL Bulbs	(123,447)	(123,447)	(123,447)	(56,126)	(56,126)	(22,416)
LED Screw-In Bulbs	(839,194)	(839,194)	(839,194)	(434,171)	(434,171)	(175,402)
Specialty LED Bulbs	(1,346,026)	(1,346,026)	(1,346,026)	(227,472)	(227,472)	(91,839)
Efficient Torchiere Floor Lamps	0	0	0	0	0	0
LED Night Lights	0	0	0	0	0	0
Occupancy Sensors	(699,389)	(699,389)	(699,389)	(194,805)	(194,805)	(78,681)
Multifamily Common Areas	0	0	0	0	0	0
Water Heating						
Heat Pump Water Heater	(937,885)	(1,875,770)	(1,875,770)	(677,363)	(677,363)	(273,478)
Solar Water Heating	6,308,684	0	0	0	0	0
Efficient Gas Tank Water Heater	2,390,659	4,710,334	0	903,474	0	365,775
Instant Gas Water Heater	4,449,282	8,766,454	0	1,682,256	0	681,066
Gravity Film Heat Exchanger	3,654,347	0	0	0	0	0
Tank Wrap	402,962	0	0	0	0	0
Pipe Wrap	4,490,184	4,490,184	4,490,184	3,379,323	3,379,323	1,358,602
Low Flow Showerheads	2,420,283	2,420,283	2,420,283	1,710,710	1,710,710	692,048

END USE	TECHNICAL POTENTIAL (MMBTU)	ECONOMIC POTENTIAL -UCT- (MMBTU)	ECONOMIC POTENTIAL -TRC- (MMBTU)	ACHIEVABLE POTENTIAL -UCT- (MMBTU)	ACHIEVABLE POTENTIAL -TRC- (MMBTU)	CONSTRAINED ACHIEVABLE –UCT- (MMBTU)
Shower Starters (with LF Showerheads)	670,558	670,558	670,558	381,890	381,890	154,602
Low Flow Faucet Aerators	2,720,628	2,720,628	2,720,628	1,864,643	1,864,643	754,513
HVAC (Envelope)						
Ceiling/Attic Insulation	8,793,191	6,531,553	6,285,828	5,116,847	4,934,267	2,072,302
Wall Insulation	6,478,320	1,467,957	967,501	897,835	741,842	363,387
Floor Insulation	4,180,390	58,371	3,271	13,434	763	5,438
Basement Wall Insulation	4,848,933	521,801	0	370,467	0	150,040
Crawlspace Wall Insulation	732,748	234,277	131,712	69,809	39,036	28,272
Air Sealing	5,055,511	3,890,293	4,134,004	2,912,164	3,106,999	1,178,685
Duct Sealing	926,669	917,545	798,866	673,328	575,709	272,468
Duct Insulation	1,283,485	817,873	499,623	515,340	264,091	208,544
Duct Location (move into conditioned space)	2,731,764	5,070,233	494,952	2,206,441	109,957	893,602
ENERGY STAR Windows	11,391,071	11,315,653	11,593,836	7,423,076	7,606,883	3,006,358
Window Film	(2,734,062)	(2,490,902)	(1,066,129)	(1,638,868)	(701,410)	(663,746)
ENERGY STAR Doors	4,684,290	0	0	0	0	0
Cool Roof	(1,606,570)	(3,109)	(3,109)	(455)	(455)	(183)
Low Income Weatherization Package	10,740,502	408,605	198,543	322,703	156,977	130,695
Steam Pipe Insulation	4,894,860	4,894,860	4,894,860	2,077,121	2,077,121	838,004
HVAC (Equipment)						
ENERGY STAR Dual Fuel Heat Pumps	133,965	133,965	148,237	37,007	41,211	14,956
Geothermal Heat Pumps	5	0	0	0	0	0
ENERGY STAR Central Air Conditioners	(2,285,365)	(2,285,365)	(2,256,845)	(445,214)	(440,955)	(180,282)
Thermostat setback strategies	18,747,726	17,176,758	17,176,758	9,046,475	9,046,475	3,629,645
Whole House Fans	(73,794)	0	0	0	0	0
Efficient Furnaces	30,685,133	29,858,475	0	9,799,103	0	3,968,134
Efficient Furnace Fans	(145,631)	(186,675)	(825,900)	(91,255)	(407,667)	(36,913)

END USE	TECHNICAL POTENTIAL (MMBTU)	ECONOMIC POTENTIAL -UCT- (MMBTU)	ECONOMIC POTENTIAL -TRC- (MMBTU)	ACHIEVABLE POTENTIAL -UCT- (MMBTU)	ACHIEVABLE POTENTIAL -TRC- (MMBTU)	CONSTRAINED ACHIEVABLE –UCT- (MMBTU)
Furnace Tune-Up	1,314,898	1,333,155	1,979,372	677,252	1,057,878	274,277
Efficient Boilers	5,018,901	6,941,197	6,728,478	2,129,003	2,098,723	862,039
Boiler Tune-up	1,708,874	1,872,413	2,353,522	934,724	1,174,224	377,984
Boiler Controls	1,908,098	1,702,834	2,306,100	891,310	1,202,157	360,825
Behavioral Programs						
Direct Feedback (In-Home Energy Display)	1,962,884	1,962,884	1,637,568	1,102,241	960,653	446,393
Indirect Feedback (Monthly Energy Use Reports)	1,368,116	1,368,116	1,424,803	1,023,510	1,063,321	417,855
Total	**143,271,591**	**109,298,652**	**62,091,152**	**53,178,705**	**39,326,470**	**21,495,414**
% of Annual 2022 Sales Forecast	*51.0%*	*38.9%*	*22.1%*	*18.9%*	*14.0%*	*7.7%*
Note: Measures in the above table with "0" potential are ones that did not pass the economic screen.						

Table 6-33 provides a list of the Top 10 residential gas savings measures for the Achievable UCT scenario. The table provides the measures ranked according to the gas savings potential. The column to the far right shows the results of the measure level cost-effectiveness screening test using the UCT to screen the measures. The measures in the table are representative of a group of comparable measures falling under the umbrella of the measure categories provided in the table. This means that there are a range of UCT ratios for measure iterations that fall into a single measure category. For example, "ENERGY STAR Windows" is a measure category which consists of several measure iterations to account for various types of efficient windows options and housing types. The table presents an average of the UCT ratios for all measures which are part of the measure categories in the Top 10.

The Top 10 measures combine to yield an estimated 46 million MMBtu savings. This accounts for more than 85% of the total residential gas savings in the Achievable UCT scenario.

Table 6-33: Top 10 Residential Gas Savings Measures in the Achievable UCT Scenario

MEASURE		2023 ENERGY (MMBTU)	% OF SECTOR SAVINGS	UCT RATIO
1	**Efficient Furnaces**	9,799,103	18.4%	1.13
2	**Thermostat setback strategies**	9,046,475	17.0%	21.98
3	**ENERGY STAR Windows**	7,423,076	14.0%	2.12
4	**Ceiling/Attic Insulation**	5,116,847	9.6%	4.68
5	**Pipe Wrap**	3,379,323	6.4%	15.68
6	**Air Sealing**	2,912,164	5.5%	6.77
7	**Duct Location (move into conditioned space)**	2,206,441	4.1%	2.15
8	**Efficient Boilers**	2,129,003	4.0%	1.59
9	**Steam Pipe Insulation**	2,077,121	3.9%	2.80

MEASURE		2023 ENERGY (MMBTU)	% OF SECTOR SAVINGS	UCT RATIO
10	Low Flow Faucet Aerators	1,864,643	3.5%	12.71
Total		**45,954,196**	**86.4%**	

6.3 ACHIEVABLE POTENTIAL BENEFITS & COSTS

The tables below provide the net present value (NPV) benefits and costs associated with the three achievable potential scenarios for the residential sector at the 5-year and 10-year periods. Table 6-34 and Table 6-35 compares the NPV benefits and costs associated with the Achievable UCT and Achievable TRC Scenarios. Both the UCT and TRC scenario benefits include avoided energy supply and demand costs, while the Achievable TRC scenario benefits also include O&M benefits, tax credits, water benefits and a carbon tax adder. The NPV costs in the Achievable UCT scenario includes only program administrator costs (incentives paid, staff labor, marketing, etc.) whereas the Achievable TRC scenario costs include both participant and program administrator costs.

Table 6-34: 5-Year Benefit-Cost Ratios for Achievable UCT vs. Achievable TRC Scenarios – Residential Sector Only

5-YEAR	NPV BENEFITS	NPV COSTS	B/C RATIO	NET BENEFITS
Achievable UCT	$3,432,366,723	$1,479,443,493	2.32	$1,952,923,230
Achievable TRC	$3,914,509,646	$1,721,305,829	2.27	$2,193,203,817

Table 6-35: 10-Year Benefit-Cost Ratios for Achievable UCT vs. Achievable TRC Scenarios – Residential Sector Only

10-YEAR	NPV BENEFITS	NPV COSTS	B/C RATIO	NET BENEFITS
Achievable UCT	$6,258,559,134	$2,603,870,491	2.40	$3,654,688,643
Achievable TRC	$7,166,982,222	$3,032,912,928	2.36	$4,134,069,295

Table 6-36 and Table 6-37 compares the NPV benefits and costs associated with the Achievable UCT and Constrained UCT Scenarios. Both scenarios compared the benefits and costs based on the UCT. However the constrained scenario's 2% of revenue spending cap on DSM results in reduced program participation and overall NPV benefits.

Table 6-36: 5-Year Benefit-Cost Ratios for Achievable UCT vs. Constrained UCT Scenarios – Residential Sector Only

5-YEAR	NPV BENEFITS	NPV COSTS	B/C RATIO	NET BENEFITS
Achievable UCT	$3,432,366,723	$1,479,443,493	2.32	$1,952,923,230
Constrained UCT	$1,397,166,850	$603,003,744	2.32	$794,163,107

Table 6-37: 10-Year Benefit-Cost Ratios for Achievable UCT vs. Constrained UCT Scenarios– Residential Sector Only

10-YEAR	NPV BENEFITS	NPV COSTS	B/C RATIO	NET BENEFITS
Achievable UCT	$6,258,559,134	$2,603,870,491	2.40	$3,654,688,643
Constrained UCT	$2,535,305,373	$1,055,704,104	2.40	$1,479,601,269

Year by year budgets for all three scenarios, broken out by incentive and administrative costs are depicted in Tables 6-38 through 6-40. Table 6-41 shows the revenue requirements for each scenario as a percentage of forecasted sector sales.

Table 6-38: Annual Program Budgets Associated with the Achievable UCT Scenario (in millions)

ACHIEVABLE UCT	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Incentives	$222.9	$241.4	$244.4	$247.0	$247.9	$248.8	$248.6	$249.6	$249.0	$248.4
Admin.	$87.3	$94.1	$95.3	$96.3	$96.7	$97.0	$97.0	$97.4	$97.1	$96.9
Total Costs	$310.3	$335.5	$339.7	$343.3	$344.6	$345.8	$345.6	$346.9	$346.1	$345.3

Table 6-39: Annual Program Budgets Associated with the Achievable TRC Scenario (in millions)

ACHIEVABLE TRC	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Incentives	$171.0	$173.5	$175.4	$175.8	$176.2	$175.7	$176.3	$175.6	$174.8	$171.0
Admin.	$65.4	$66.3	$67.1	$67.3	$67.4	$67.2	$67.5	$67.2	$66.9	$65.4
Total Costs	$236.4	$239.8	$242.6	$243.1	$243.7	$243.0	$243.8	$242.7	$241.7	$236.4

Table 6-40: Annual Program Budgets Associated with the Constrained UCT Scenario (in millions)

CONSTRAINED UCT	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Incentives	$97.3	$97.5	$98.1	$98.6	$99.1	$99.7	$100.3	$100.8	$101.4	$97.3
Admin.	$37.9	$38.0	$38.2	$38.4	$38.7	$38.9	$39.1	$39.3	$39.6	$37.9
Total Costs	$135.2	$135.5	$136.3	$137.0	$137.8	$138.6	$139.4	$140.2	$141.0	$135.2

Table 6-41: Annual Achievable Scenario Budgets as a % of Annual Sector Revenue

	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Achievable UCT	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%	4.9%	4.9%	5.0%
Achievable TRC	3.5%	3.5%	3.6%	3.5%	3.5%	3.5%	3.5%	3.5%	3.4%	3.5%
Constrained UCT	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%

7 COMMERCIAL ELECTRIC AND NATURAL GAS ENERGY EFFICIENCY POTENTIAL ESTIMATES

This section provides electric and natural gas energy efficiency potential estimates for the commercial sector in Michigan. Estimates of technical, economic and achievable potential are provided in separate sections for electric and natural gas.

7.1 COMMERCIAL ELECTRIC ENERGY EFFICIENCY POTENTIAL

According to 2012 historical sales data[41], the commercial sector accounts for approximately 37% of retail electric sales in Michigan, but only 11% of the total retail customers. The average commercial electric customer in Michigan consumes roughly 74,000 kWh annually. Comparatively, the average residential consumer in Michigan uses approximately 8,200 kWh per year. Commercial kWh sales over the period 2002 to 2012 have increased by a total of 6.9%, peaking at 40,047 million kWh in 2007 and then declining to a 2012 level of 38,367 million kWh. For this study, commercial electric sales are estimated to remain relatively stable at their 2012 level over the 10 year study period of 2014 – 2023.[42]

7.1.1 Electric Energy Efficiency Measures Examined

For the commercial sector, there were 182 unique energy efficiency measures included in the electric energy savings potential analysis. Table 7-1 provides a brief description of the types of measures included for each end use in the commercial sector. The list of measures was developed based on a review of the Michigan Energy Measures Database (MEMD), measures found in other Technical Reference Manuals (TRMs) and measures included in other commercial energy efficiency potential studies. For each measure, the analysis considered incremental costs, energy and demand savings, and measure useful lives.

Table 7-1: Types of Electric Energy Efficiency Measures Included in the Commercial Sector Analysis

END USE TYPE	END USE DESCRIPTION	MEASURES INCLUDED
Appliances, Computers & Office Equipment	Office Equipment Improvements	• Appliances • High Efficiency Office Equipment • Smart Power Strips • Computer Energy Management Controls
Compressed Air	Compressor Equipment	• Efficient Air Compressors • Automatic Drains • Cycling and High Efficiency Dryers • Low Pressure Drop-Filters • Air-Entraining Air Nozzles • Receiver Capacity Addition • Compressed Air Audits, Leak Repair, and Flow Control • Barrel Wraps
Cooking	Cooking Equipment Improvements	• Efficient Cooking Equipment
Envelope	Space Heating and Space Cooling	• Building Envelope Improvements • Cool Roofing • Integrated Building Design
HVAC Controls	Space Cooling and Space Heating	• Programmable Thermostats • EMS Installation/Optimization • Hotel Guest Room Occupancy Control System • Retrocommissioning & Commissioning

[41] U.S. Energy Information Administration

[42] GDS forecast based on kWh sales forecasts provided by DTE Energy and Consumers Energy (CE) and historical commercial kWh sales trends for the state as a whole.

END USE TYPE	END USE DESCRIPTION	MEASURES INCLUDED
Lighting	Lighting Improvements	• Efficient Lighting Equipment • Fixture Retrofits • Ballast Replacement • Premium Efficiency T8 and T5 • High Bay Lighting Equipment • LED Bulbs and Fixtures • Light Tube • CFL Retrofits • Lighting Controls • Efficient Design for New Construction
Other	Transformer Equipment Other	• Efficient Transformers • Vending Miser for Non-Refrig Equip • Optimized Snow and Ice Melt Controls • EC Plug Fans in Data Centers • Engine Block Heater Timer • NEMA Premium Efficiency Motors
Pools	Pool Equipment	• Efficient Equipment and Controls • Heat Pump Pool Heaters • Solar Water Heating
Refrigeration	Refrigeration Improvements	• Vending Misers • Refrigerated Case Covers • Economizers • Efficient Refrigeration • Upgrades Motors and Controls • Door Heater Controls • Efficient Compressors and Controls • Door Gaskets and Door Retrofits • Refrigerant Charging Correction • Ice-Makers
Space Cooling	Cooling System Upgrades	• Efficient Chillers • Efficient Cooling Equipment • Ground/Water Source Heat Pump • Chiller Tune-up/Diagnostics • High Efficiency Pumps
Space Heating	Heating System Improvements	• Efficient Heating Equipment • Ground/Water Source Heat Pump • Efficient Heating Pumps, Motors, and Controls
Ventilation	Ventilation Equipment	• Enthalpy Economizer • Variable Speed Drive Controls • Improved Duct Sealing • Electronically-Commutated Permanent Magnet Motors • Destratification Fans • Controlled Ventilation Optimization • Demand Controlled Ventilation • High Performance Air Filters
Water Heating	Water Heating Improvements	• Efficient Equipment • High Efficiency HW Appliances • Ozone Laundry System • Low Flow Equipment • Pipe and Tank Insulation • Heat Recovery Systems • Efficient HW Pump and Controls • Solar Water Heating System

7.1.2 Technical and Economic Potential Electric Savings

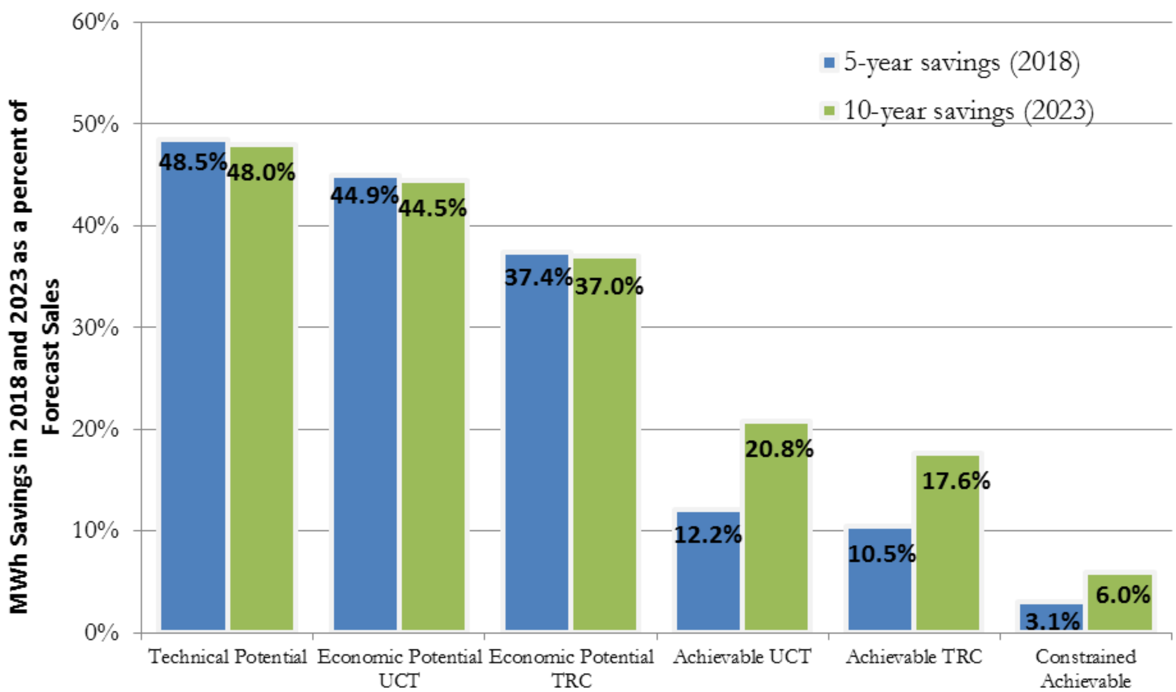
This section presents estimates for electric technical, economic, and achievable savings potential for the commercial sector. Each of the tables in the technical, economic and achievable sections present the respective potential for efficiency savings expressed as cumulative annual savings (MWh) and percentage of commercial sector forecast annual MWh sales. Data is provided for a 5 and 10-year horizon for Michigan

This energy efficiency potential study considers the impacts of the December 2007 Energy and Independence and Security Act (EISA) as an improving code standard for the commercial sector. EISA improves the baseline efficiency of compact fluorescent lamps (CFL), general service fluorescent lamps (GSFL), high intensity discharge (HID) lamps and ballasts and motors, all applicable in the commercial sector.

SUMMARY OF FINDINGS

Figure 7-1 illustrates the estimated energy efficiency savings potential in Michigan for each of the scenarios included in this study.

Figure 7-1: Summary of Commercial Electric Energy Efficiency Potential as a % of Sales Forecasts



The potential savings estimates are expressed as cumulative annual 5-year and 10-year savings, as percentages of the respective 2018 and 2023 commercial sector sales forecasts. The technical potential is 48.5% in 2018 and 48.0% in 2023. The 5-year and 10-year economic potential is 44.9% and 44.5% based on the Utility Cost Test (UCT) screen, assuming an incentive level equal to 50% of the measure cost. Based on a measure-level screen using the TRC Test, the economic potential is 37.4% in 2018 and 37.0% in 2023. The slight drop from technical potential to economic potential indicates that most measures are cost-effective.

The 5-year and 10-year achievable potential savings are: 12.2% and 20.8% for the Achievable UCT scenario; 10.5% and 17.6% for the Achievable TRC scenario; and 3.1% and 6.0% for the Constrained Achievable scenario. The Achievable UCT scenario assumes 50% incentives and includes measures that passed the UCT Test. The Achievable TRC scenario also assumes 50% incentives but includes only measures that passed the cost-effectiveness screen based on the TRC Test. Last, the Constrained Achievable scenario is a subset of the Achievable UCT scenario, assuming a spending cap on non-residential DSM approximately equal to 2% of future annual commercial and industrial revenue. The percent of the non-residential spending cap allocated to the commercial sector is based on the percentage of total non-residential UCT savings that the commercial sector represents. This presumes that the total non-residential spending cap will be allocated at the sector level based on where the savings opportunities are found.

TECHNICAL POTENTIAL

Technical potential represents the quantification of savings that can be realized if energy-efficiency measures passing the qualitative screening are applied in all feasible instances, regardless of cost. Table 7-2 shows that it is technically feasible to save approximately 18.5 million MWh annually in the commercial sector by 2018, and approximately 18.6 million MWh annually by 2023 across Michigan, representing 48.5% of the commercial sales forecast in 2018, and 48.0% of the commercial sales forecast in 2023. Lighting represents the majority of the energy efficiency savings potential at over 40% of 10-yr savings, followed by Refrigeration and Ventilation at over 10% each, while cooking, pools, and space heating represent the smallest shares, each with 1 percent or less of 10-yr savings. Table 7-3 shows the demand savings potential in 2018 and 2023. The five and ten year summer peak demand savings technical potential is 5,715 MW and 5,741 MW, respectively, which is 53.8% and 53.2% of the peak forecasts for 2018 and 2023 respectively.

Table 7-2: Commercial Sector Technical Potential Electric Energy Savings by End Use

END USE	2018 ENERGY SAVINGS (MWH)	% OF 2018 TOTAL	2023 ENERGY SAVINGS (MWH)	% OF 2023 TOTAL
Appliances, Computers, Office Equipment	928,899	5%	933,013	5%
Compressed Air	621,671	3%	621,671	3%
Cooking	128,779	1%	129,374	1%
Envelope	500,791	3%	512,810	3%
HVAC Controls	464,362	3%	465,570	3%
Lighting	7,967,141	43%	7,995,560	43%
Other	646,701	3%	649,564	3%
Pools	25,847	0%	25,946	0%
Refrigeration	3,466,859	19%	3,478,837	19%
Space Cooling	425,425	2%	426,706	2%
Space Heating	256,066	1%	256,850	1%
Ventilation	2,741,339	15%	2,752,763	15%
Water Heating	351,337	2%	352,481	2%
Total	**18,525,217**	**100%**	**18,601,147**	**100%**
% of Annual Sales Forecast	*48.5%*		*48.0%*	

Table 7-3: Commercial Sector Technical Potential Electric Demand Savings

	Summer Peak Demand	
	2018	2023
Summary	MW	MW
Total	**5,715**	**5,741**
% of Forecast Peak	*53.8%*	*53.2%*

ECONOMIC POTENTIAL

Economic potential is a subset of technical potential and only includes measures that are cost-effective. This analysis includes two estimates of economic potential. One cost-effectiveness screen is based on the UCT and a second economic potential scenario was screened using the TRC Test. In both scenarios, the utility incentive was assumed to be equal to 50% of the measure incremental cost. The UCT was used for this study because it is mandated in Michigan to be the primary cost-effectiveness test used when considering energy efficiency programs. The TRC Test was also included because it also considers the cost assumed by the participant as well as all utility costs. Eighty seven percent of all measures that were included in the electric potential analysis passed the UCT and 76% of all measures passed the TRC Test.

Table 7-4 indicates that the economic potential based on the UCT screen is approximately 17.2 million MWh annually by 2018, and the economic potential increases to 17.3 million MWh annually by 2023. This represents 44.9% and 44.5% of commercial sales in 2018 and 2023. Lighting, refrigeration, and ventilation make up a majority of the savings. Table 7-5 shows the peak demand savings economic potential in 2018 and 2023. The five and ten year summer peak demand savings economic potential is 5,300 MW and 5,325 MW, respectively, which is 49.9% and 49.3% of the peak forecasts in 2018 and 2013 respectively.

Table 7-4: Commercial Sector Economic Potential (UCT) Electric Energy Savings by End Use

End Use	2018 Energy Savings (MWh)	% of 2018 Total	2023 Energy Savings (MWh)	% of 2023 Total
Appliances, Computers, Office Equipment	712,442	4%	715,598	4%
Compressed Air	620,398	4%	620,398	4%
Cooking	122,452	1%	123,019	1%
Envelope	221,331	1%	226,643	1%
HVAC Controls	464,362	3%	465,570	3%
Lighting	7,706,402	45%	7,733,891	45%
Other	646,701	4%	649,564	4%
Pools	25,847	0%	25,946	0%
Refrigeration	3,418,820	20%	3,430,632	20%
Space Cooling	277,063	2%	277,898	2%
Space Heating	175,846	1%	176,384	1%
Ventilation	2,453,815	14%	2,464,040	14%
Water Heating	341,168	2%	342,278	2%
Total	**17,186,647**	**100%**	**17,251,862**	**100%**
% of Annual Sales Forecast	*44.9%*		*44.5%*	

Table 7-5: Commercial Sector Economic Potential (UCT) Electric Demand Savings

	Summer Peak Demand	
	2018	2023
Summary	MW	MW
Total	5,300	5,325
% of Peak	*49.9%*	*49.3%*

Table 7-6 shows that the economic potential based on the TRC screen is nearly 14.3 million MWh annually by 2018, and the economic potential increases less than 100,000 MWh by 2023. This represents 37.4% of the commercial MWh sales forecast for 2018 and 37.0% for 2023. As with UCT economic potential, lighting, refrigeration, and ventilation again make up a majority of the economic TRC savings potential. Table 7-7 shows the economic demand savings potential in 2018 and 2023. The five and ten year summer peak demand savings potential is 4,496 MW and 4,519 MW, respectively, which is 42.3% and 41.9% of the peak forecasts for the commercial sector for those years.

Table 7-6: Commercial Sector Economic Potential (TRC) Electric Savings by End Use

End Use	2018 Energy Savings (MWh)	% of 2018 Total	2023 Energy Savings (MWh)	% of 2023 Total
Appliances, Computers, Office Equipment	693,228	5%	696,295	5%
Compressed Air	620,398	4%	620,398	4%
Cooking	108,343	1%	108,844	1%
Envelope	108,078	1%	113,390	1%
HVAC Controls	464,362	3%	465,570	3%
Lighting	5,389,648	38%	5,414,894	38%
Other	619,740	4%	622,524	4%
Pools	25,847	0%	25,946	0%
Refrigeration	3,376,105	24%	3,387,734	24%
Space Cooling	276,636	2%	277,469	2%
Space Heating	54,889	0%	55,480	0%
Ventilation	2,208,697	15%	2,217,793	15%
Water Heating	336,890	2%	337,989	2%
Total	14,282,862	100%	14,344,326	100%
% of Annual Sales Forecast	*37.4%*		*37.0%*	

Table 7-7: Commercial Sector Economic Potential Electric Demand Savings

	Summer Peak Demand	
	2018	2023
Summary	MW	MW
Total	4,496	4,519
% of Peak	*42.3%*	*41.9%*

7.1.3 Achievable Potential Savings in the Commercial Sector

Achievable potential is an estimate of energy savings that can feasibly be achieved given market barriers and equipment replacement cycles. This study estimated achievable potential for three scenarios. The Achievable UCT Scenario determines the achievable potential of all measures that passed the UCT economic screening assuming incentives equal to 50% of the measure cost. Unlike the economic potential, the commercial achievable potential takes into account the estimated market adoption of energy efficiency measures based on the incentive level and the natural replacement cycle of equipment. The second scenario, Achievable TRC, also assumes incentives set at 50% of the measure incremental cost, but only includes measures that passed the TRC Test economic screening. The third scenario, Constrained UCT, assumes a spending cap equal to 2% of annual utility revenues, thereby limiting utilities from reaching the ultimate potential estimated in the Achievable UCT scenario.

7.1.3.1 UCT vs. TRC

Tables 7-8 through 7-11 show the estimated cumulative annual savings for the Achievable UCT and Achievable TRC scenarios over 5 and 10 year time horizons. As noted above, both scenarios assume an incentive level approximately equal to 50% of the incremental measure cost and include estimated 10-year market adoption rates based on incentive levels and equipment replacement cycles. However, because more measures pass the UCT relative to the TRC Test, the Achievable UCT scenario is able to include additional measures that would result in greater savings potential over the next five and ten years. Overall the Achievable UCT scenario results in an achievable potential that is approximately 1 million MWh greater over the next decade, than the achievable TRC scenario.

Table 7-8: Commercial Achievable UCT Potential Electric Energy Savings by End Use

END USE	2018 ENERGY SAVINGS (MWH)	% OF 2018 TOTAL	2023 ENERGY SAVINGS (MWH)	% OF 2023 TOTAL
Appliances, Computers, Office Equipment	185,083	4%	355,308	4%
Compressed Air	221,662	5%	329,391	4%
Cooking	32,946	1%	65,892	1%
Envelope	13,634	0%	20,618	0%
HVAC Controls	194,726	4%	278,618	3%
Lighting	1,850,030	40%	3,511,776	44%
Other	101,445	2%	185,126	2%
Pools	9,231	0%	15,656	0%
Refrigeration	1,242,660	27%	1,958,394	24%
Space Cooling	73,050	2%	112,157	1%
Space Heating	61,225	1%	89,739	1%
Ventilation	554,381	12%	963,128	12%
Water Heating	111,923	2%	171,896	2%
Total	**4,651,994**	**100%**	**8,057,699**	**100%**
% of Annual Sales Forecast	*12.2%*		*20.8%*	

Table 7-9: Commercial Achievable UCT Potential Electric Demand Savings

	Summer Peak Demand	
	2018	2023
Summary	MW	MW
Total	1,292	2,433
% of Peak	*12.2%*	*22.6%*

Table 7-10: Commercial Achievable TRC Potential Electric Energy Savings by End Use

End Use	2018 Energy Savings (MWh)	% of 2018 Total	2023 Energy Savings (MWh)	% of 2023 Total
Appliances, Computers, Office Equipment	183,669	5%	352,481	5%
Compressed Air	221,662	6%	329,391	5%
Cooking	29,293	1%	58,586	1%
Envelope	10,967	0%	16,213	0%
HVAC Controls	194,726	5%	278,618	4%
Lighting	1,328,909	33%	2,503,571	37%
Other	89,843	2%	168,312	2%
Pools	9,231	0%	15,656	0%
Refrigeration	1,229,658	31%	1,934,311	28%
Space Cooling	72,972	2%	112,002	2%
Space Heating	12,378	0%	19,957	0%
Ventilation	511,177	13%	876,720	13%
Water Heating	110,063	3%	169,284	2%
Total	4,004,548	100%	6,835,102	100%
% of Annual Sales Forecast	*10.5%*		*17.6%*	

Table 7-11: Commercial Achievable TRC Potential Electric Demand Savings

	Summer Peak Demand	
	2018	2023
Summary	MW	MW
Total	1,127	2,128
% of Peak	*10.6%*	*19.7%*

7.1.3.2 Achievable UCT vs. Constrained UCT

Although the Achievable UCT assumes incentives are set and capped at 50% of the incremental measure cost, and that measures are typically replaced at the end of their useful life, the Achievable UCT scenario also assumes no DSM spending cap to reach all potential participants. In the Constrained UCT scenario, the analysis assumes a utility spending cap approximately equal to 2% of Michigan annual utility revenues. The percent of the non-residential spending cap allocated to the commercial sector is based on the percentage of total non-residential UCT savings that the commercial sector represents. This presumes that the total non-residential spending cap will be allocated at the sector level based on where the savings opportunities are found. To model the impact of a spending cap the market penetration of all cost effective measures was reduced by the ratio of capped spending to uncapped spending that would be required to achieve the Achievable UCT scenario savings potential.

Tables 7-12 and 7-13 show the estimated savings for the Constrained UCT scenario over 5 and 10 year time horizons. The 5-year and 10-year Constrained UCT potential cumulative annual savings estimates are nearly 1.2 million MWh and just over 2.3 million MWh respectively. This equates to 3.1% and 6.0% of sector sales in 2018 and 2023. The five and ten year demand savings estimates in the Constrained UCT scenario are presented in Table 7-13.

Table 7-12: Commercial Constrained Achievable Electric Energy Efficiency Savings by End Use

END USE	2018 ENERGY SAVINGS (MWH)	% OF 2018 TOTAL	2023 ENERGY SAVINGS (MWH)	% OF 2023 TOTAL
Appliances, Computers, Office Equipment	25,948	2%	53,848	2%
Compressed Air	48,550	4%	77,566	3%
Cooking	141,079	12%	272,520	12%
Envelope	15,300	1%	24,241	1%
HVAC Controls	313,066	26%	567,974	24%
Lighting	47,828	4%	114,952	5%
Other	3,418	0%	5,612	0%
Pools	28,098	2%	47,084	2%
Refrigeration	8,522	1%	18,977	1%
Space Cooling	477,777	40%	1,009,373	43%
Space Heating	2,342	0%	4,371	0%
Ventilation	58,556	5%	98,082	4%
Water Heating	18,338	2%	31,455	1%
Total	**1,188,821**	**100%**	**2,326,054**	**100%**
% of Annual Sales Forecast	***3.1%***		***6.0%***	

Table 7-13: Commercial Constrained Achievable Electric Demand Savings

	SUMMER PEAK DEMAND	
	2018	**2023**
Summary	**MW**	**MW**
Total	**334**	**737**
% of Peak	***3.1%***	***6.8%***

Figure 7-2 shows the estimated 10-year cumulative annual energy efficiency savings potential broken out by end use across the entire commercial sector for the Constrained UCT scenario. The space cooling end use shows the largest potential for energy efficiency savings by a wide margin at nearly 1,010,000 MWh annually, or 43% of total savings, in the Constrained UCT scenario, with HVAC Controls and Cooking end uses accounting for 24% and 12% respectively.

Figure 7-2: Commercial Sector 2023 Constrained UCT Potential Savings by End Use

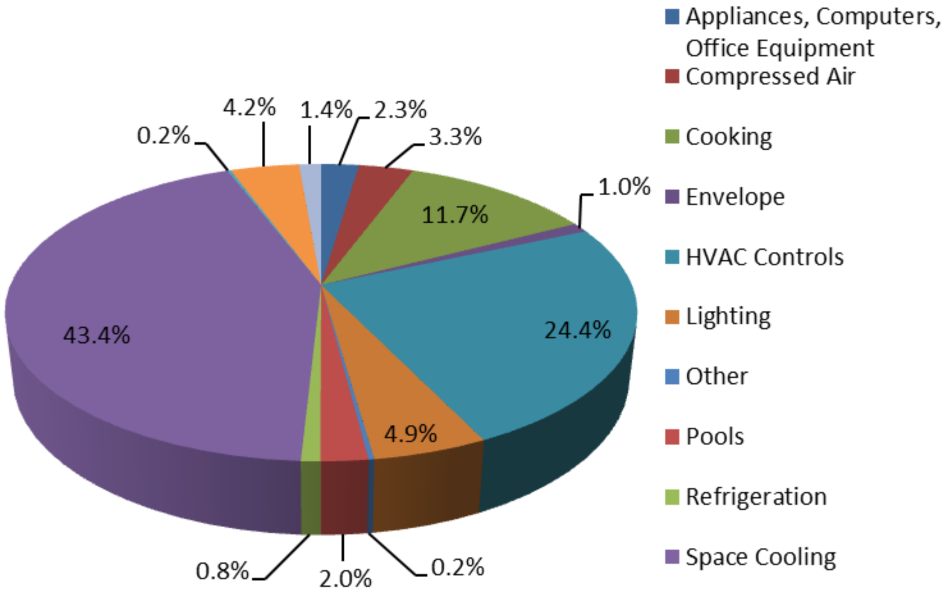
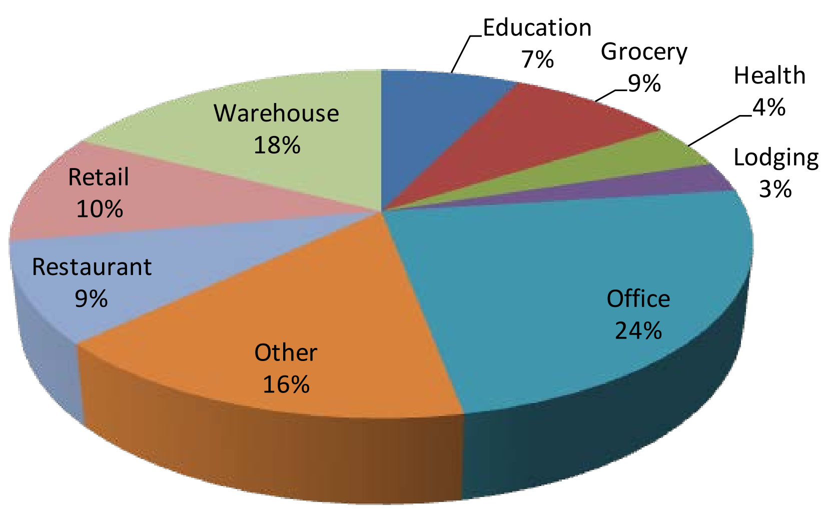


Figure 7-3 shows the breakdown of estimated savings in 2023 by building type for the Constrained UCT scenario. The vast majority of savings come from existing/turnover measures, meaning energy efficient equipment is installed to replace existing equipment that has failed, with less than 1% of savings potential coming from new construction. Approximately 24% of the potential savings are found in Offices, followed by 18% in Warehouses and 16% in Other building types.

Figure 7-3: Commercial Constrained UCT Savings in 2023 by Building Type



7.1.4 Cumulative Annual Achievable Electric Savings Potential

Tables 7-14, Table 7-15 and Table 7-16 show cumulative annual electric energy savings for all achievable scenarios for each year across the 10-year horizon for the study, broken out by end use. Table 7-17, Table 7-18 and Table 7-19 shows cumulative annual demand (MW) savings for all three achievable potential scenarios for each year across the 10-year time horizon for the study, broken out by end use.

Table 7-14: Cumulative Annual Commercial Sector Electric Energy Savings in the Achievable UCT Potential Scenario by End Use (MWH)

END USE	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Appliances, Computers, Office Equipment	33,674	71,062	110,307	149,552	185,083	220,613	254,287	287,961	321,634	355,308
Compressed Air	18,698	65,878	127,300	188,723	221,662	254,601	273,298	291,996	310,694	329,391
Cooking	6,589	13,178	19,768	26,357	32,946	39,535	46,124	52,714	59,303	65,892
Envelope	1,230	4,124	7,848	11,573	13,634	15,696	16,927	18,157	19,388	20,618
HVAC Controls	14,007	55,724	111,294	166,865	194,726	222,588	236,596	250,603	264,611	278,618
Lighting	365,551	757,358	1,130,550	1,503,418	1,850,030	2,196,642	2,530,126	2,857,343	3,184,560	3,511,776
Other	16,292	37,025	59,979	82,932	101,445	119,957	136,249	152,541	168,834	185,126
Pools	1,215	3,131	5,398	7,665	9,231	10,797	12,011	13,226	14,441	15,656
Refrigeration	129,974	391,679	719,250	1,046,820	1,242,660	1,438,499	1,568,473	1,698,447	1,828,420	1,958,394
Space Cooling	6,973	22,431	42,133	61,834	73,050	84,265	91,238	98,211	105,184	112,157
Space Heating	4,885	17,948	35,099	52,251	61,225	70,199	75,084	79,969	84,854	89,739
Ventilation	78,109	192,626	325,347	458,068	554,381	650,694	728,802	806,911	885,019	963,128
Water Heating	10,696	34,379	64,556	94,733	111,923	129,112	139,808	150,504	161,200	171,896
Total	**687,893**	**1,666,542**	**2,758,829**	**3,850,790**	**4,651,994**	**5,453,199**	**6,109,024**	**6,758,582**	**7,408,141**	**8,057,699**
% of Annual Sales Forecast	*1.8%*	*4.4%*	*7.3%*	*10.1%*	*12.2%*	*14.2%*	*15.9%*	*17.5%*	*19.2%*	*20.8%*

Table 7-15: Cumulative Annual Commercial Sector Electric Energy Savings in the Achievable TRC Potential Scenario by End Use (MWH)

End Use	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Appliances, Computers, Office Equipment	33,391	70,496	109,458	148,421	183,669	218,917	252,308	285,699	319,090	352,481
Compressed Air	18,698	65,878	127,300	188,723	221,662	254,601	273,298	291,996	310,694	329,391
Cooking	5,859	11,717	17,576	23,435	29,293	35,152	41,011	46,869	52,728	58,586
Envelope	906	3,243	6,294	9,346	10,967	12,588	13,495	14,401	15,307	16,213
HVAC Controls	14,007	55,724	111,294	166,865	194,726	222,588	236,596	250,603	264,611	278,618
Lighting	251,108	528,472	804,297	1,079,731	1,328,909	1,578,087	1,814,138	2,043,949	2,273,760	2,503,571
Other	15,409	33,662	53,337	73,012	89,843	106,675	122,084	137,493	152,903	168,312
Pools	1,215	3,131	5,398	7,665	9,231	10,797	12,011	13,226	14,441	15,656
Refrigeration	127,805	386,862	711,545	1,036,227	1,229,658	1,423,089	1,550,895	1,678,700	1,806,506	1,934,311
Space Cooling	6,957	22,400	42,086	61,772	72,972	84,172	91,130	98,087	105,045	112,002
Space Heating	1,396	3,991	7,187	10,382	12,378	14,373	15,769	17,165	18,561	19,957
Ventilation	69,468	175,344	299,424	423,505	511,177	598,849	668,316	737,784	807,252	876,720
Water Heating	10,573	33,857	63,496	93,135	110,063	126,991	137,564	148,137	158,711	169,284
Total	**556,793**	**1,394,779**	**2,358,693**	**3,322,217**	**4,004,548**	**4,686,880**	**5,228,615**	**5,764,110**	**6,299,606**	**6,835,102**
% of Annual Sales Forecast	*1.5%*	*3.7%*	*6.2%*	*8.7%*	*10.5%*	*12.2%*	*13.6%*	*14.9%*	*16.3%*	*17.6%*

Table 7-16: Cumulative Annual Commercial Sector Electric Energy Savings in Constrained UCT Potential Scenario by End Use (MWH)

END USE	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Appliances, Computers, Office Equipment	9,670	18,462	27,764	37,212	47,828	60,243	74,541	88,791	101,390	114,952
Compressed Air	5,370	16,203	30,799	45,736	58,556	68,009	77,522	84,729	91,117	98,082
Cooking	1,892	3,442	5,004	6,590	8,522	10,439	12,574	14,718	16,825	18,977
Envelope	353	1,034	1,917	2,813	3,418	4,018	4,416	4,817	5,210	5,612
HVAC Controls	4,023	13,832	27,004	40,382	48,550	56,659	61,197	65,909	71,427	77,566
Lighting	104,979	197,115	284,957	374,791	477,777	579,870	689,041	796,729	901,243	1,009,373
Other	4,679	9,554	14,995	20,521	25,948	31,346	37,014	42,774	48,401	53,848
Pools	349	800	1,337	1,883	2,342	2,797	3,191	3,586	3,975	4,371
Refrigeration	37,326	98,867	176,504	255,365	313,066	374,510	425,146	475,781	520,452	567,974
Space Cooling	2,002	5,638	10,307	15,050	18,338	21,602	23,862	26,130	28,442	31,455
Space Heating	1,403	4,475	8,540	12,669	15,300	17,912	19,494	21,084	22,646	24,241
Ventilation	22,431	49,361	80,819	112,477	141,079	169,450	195,809	221,625	246,969	272,520
Water Heating	3,072	8,641	15,794	23,058	28,098	33,101	36,597	40,118	43,579	47,084
Total	**197,549**	**427,423**	**685,739**	**948,548**	**1,188,821**	**1,429,958**	**1,660,405**	**1,886,791**	**2,101,676**	**2,326,054**
% of Annual Sales Forecast	*0.5%*	*1.1%*	*1.8%*	*2.5%*	*3.1%*	*3.7%*	*4.3%*	*4.9%*	*5.4%*	*6.0%*

Table 7-17: Cumulative Annual Commercial Sector Electric Demand Savings in the Achievable UCT Potential Scenario by End Use (MW)

END USE	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Appliances, Computers, Office Equipment	99	199	298	398	497	597	696	796	895	994
Compressed Air	4	14	27	41	48	55	58	62	66	69
Cooking	2	5	7	9	11	14	16	18	21	23
Envelope	1	2	3	5	6	7	7	8	8	9
HVAC Controls	0	1	1	1	2	2	2	2	2	3
Lighting	74	156	233	310	380	450	516	581	645	710
Other	7	14	21	28	34	41	48	55	62	69
Pools	1	2	3	4	5	6	6	7	8	9
Refrigeration	13	39	71	102	122	141	155	168	182	195
Space Cooling	2	4	6	8	10	11	13	15	17	19
Space Heating	2	8	15	22	25	29	31	33	36	38
Ventilation	27	55	82	109	136	164	191	218	245	273
Water Heating	2	5	9	13	15	18	19	21	23	24
Total	**234**	**501**	**775**	**1,050**	**1,292**	**1,534**	**1,760**	**1,984**	**2,209**	**2,433**
% of Annual Demand Forecast	*2.2%*	*4.7%*	*7.3%*	*9.9%*	*12.2%*	*14.4%*	*16.5%*	*18.5%*	*20.6%*	*22.6%*

Table 7-18: Cumulative Annual Commercial Sector Electric Demand Savings in the Achievable TRC Potential Scenario by End Use (MW)

END USE	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Appliances, Computers, Office Equipment	99	199	298	398	497	597	696	795	895	994
Compressed Air	4	14	27	41	48	55	58	62	66	69
Cooking	2	4	6	8	11	13	15	17	19	21
Envelope	0	1	3	4	5	5	6	6	6	7
HVAC Controls	0	1	1	1	2	2	2	2	2	3
Lighting	52	111	171	230	282	334	382	429	476	523
Other	7	14	21	28	34	41	48	55	62	69
Pools	1	2	3	4	5	6	6	7	8	9
Refrigeration	13	38	70	101	120	140	153	166	179	192
Space Cooling	2	4	6	8	10	11	13	15	17	18
Space Heating	1	1	2	2	3	3	4	4	5	5
Ventilation	19	39	58	78	97	117	136	155	175	194
Water Heating	2	5	9	13	15	17	19	20	22	24
Total	**202**	**432**	**674**	**915**	**1,127**	**1,340**	**1,538**	**1,735**	**1,931**	**2,128**
% of Annual Demand Forecast	*1.9%*	*4.1%*	*6.4%*	*8.6%*	*10.6%*	*12.6%*	*14.4%*	*16.2%*	*18.0%*	*19.7%*

Table 7-19: Cumulative Annual Commercial Sector Electric Demand Savings in Constrained UCT Potential Scenario by End Use (MW)

END USE	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Appliances, Computers, Office Equipment	29	52	76	100	129	164	205	245	282	322
Compressed Air	1	3	7	10	12	14	16	18	19	20
Cooking	1	1	2	2	3	4	4	5	6	7
Envelope	0	0	1	1	1	2	2	2	2	2
HVAC Controls	0	0	0	0	0	1	1	1	1	1
Lighting	21	41	59	77	98	119	141	163	183	205
Other	2	4	5	7	9	11	13	16	18	21
Pools	0	0	1	1	1	1	2	2	2	2
Refrigeration	4	10	17	25	31	37	42	47	52	57
Space Cooling	1	1	1	2	2	3	4	4	5	5
Space Heating	1	2	4	5	6	7	8	9	10	10
Ventilation	8	14	21	27	35	43	52	61	70	79
Water Heating	0	1	2	3	4	5	5	6	6	7
Total	**67**	**130**	**195**	**261**	**334**	**411**	**495**	**578**	**656**	**737**
% of Annual Demand Forecast	*0.6%*	*1.2%*	*1.8%*	*2.5%*	*3.1%*	*3.8%*	*4.6%*	*5.4%*	*6.1%*	*6.8%*

7.1.5 Commercial Electric Savings Summary by Measure Group

Table 7-20 below provides an end-use breakdown of the commercial electric savings potential estimates for technical and economic potential, and each of the three achievable potential scenarios. The table indicates how the savings potential decreases systematically from the technical potential scenario to the Constrained UCT potential scenario as additional limiting factors such as cost-effectiveness requirements and anticipated market adoption at given funding levels are introduced.

Table 7-20: Commercial Sector Cumulative Annual Electric Savings Potential by End-Use and Measure by 2023

END USE	TECHNICAL POTENTIAL (MWH)	ECONOMIC UCT (MWH)	ECONOMIC TRC (MWH)	ACHIEVABLE UCT (MWH)	ACHIEVABLE TRC (MWH)	CONSTRAINED ACHIEVABLE (MWH)
Appliances, Computers, Office Equipment						
Office Equipment / Appliances	640,360	640,360	621,057	318,165	315,337	102,909
PC Network Energy Management Controls replacing no central control	75,238	75,238	75,238	37,143	37,143	12,044
"Smart" Power Strip/Monitor Power Management Software/UPS	217,415	0	0	0	0	0
Compressed Air						
Barrel Wraps Inj Mold and Extruders	93,709	93,709	93,709	44,716	44,716	14,252
Compressed Air Audits & Leak Repair	155,844	155,844	155,844	100,609	100,609	32,850
Dryers/Receiver Capacity/Outdoor Air Intake	32,774	31,501	31,501	14,387	14,387	4,066
Efficient Air Compressors	81,772	81,772	81,772	26,103	26,103	7,518
Nozzles / Automatic Drains/Drop Filters/Flow Control	256,562	256,562	256,562	143,119	143,119	39,274
Variable Displacement Air Compressor	1,011	1,011	1,011	457	457	123
Cooking						
HE Fryer	6,356	0	0	0	0	0
HE Griddle	11,074	11,074	0	5,620	0	1,619
HE Holding Cabinet	37,962	37,962	37,962	19,850	19,850	5,717
HE Oven	12,717	12,717	9,617	6,914	5,228	1,991
HE Steamer	57,242	57,242	57,242	31,122	31,122	8,963
Induction Cooktops	4,024	4,024	4,024	2,386	2,386	687
Envelope						
Integrated Building Design	10,624	10,624	10,624	1,911	1,911	550
Windows, Insulation, Cool Roofing	502,187	216,019	102,766	18,708	14,302	5,062
HVAC Controls						
EMS Installation / Optimization	239,210	239,210	239,210	147,259	147,259	39,523
Hotel Guest Room Occupancy Control System	2,546	2,546	2,546	1,531	1,531	460

END USE	TECHNICAL POTENTIAL (MWH)	ECONOMIC UCT (MWH)	ECONOMIC TRC (MWH)	ACHIEVABLE UCT (MWH)	ACHIEVABLE TRC (MWH)	CONSTRAINED ACHIEVABLE (MWH)
Programmable Thermostats	92,486	92,486	92,486	48,493	48,493	13,110
Retrocommissioning / Commissioning	131,328	131,328	131,328	81,335	81,335	24,473
Lighting						
CFL Lighting Efficiency	400,586	400,586	400,549	216,558	216,558	65,913
Fluorescent Tube Lighting Efficiency	2,541,825	2,541,825	970,283	802,591	222,908	229,439
LED Lighting Efficiency	809,494	567,337	550,531	255,499	244,584	74,053
Lighting Controls and Design	3,999,642	3,980,129	3,492,753	2,125,176	1,819,521	607,726
Other Lighting Efficiency	244,014	244,014	778	111,953	0	32,242
Other						
Commercial Clothes washers - Non-Water Heating Savings	2,227	2,227	0	842	0	260
EC Plug Fans	16,065	16,065	16,065	6,914	6,914	1,991
Engine Block Heater Timer	30,710	30,710	30,710	19,825	19,825	6,291
NEMA Premium Transformer	531,700	531,700	531,700	113,135	113,135	32,582
Optimized Snow and Ice Melt Controls	44,049	44,049	44,049	28,437	28,437	7,632
Vendor Miser for Non-Refrig Equipment	24,813	24,813	0	15,971	0	5,090
Pools						
Energy Efficient Pool Pump with controls	14,857	14,857	14,857	8,513	8,513	2,452
Heat Pump Pool Heater	6,978	6,978	6,978	4,505	4,505	1,209
High efficiency spas/hot tubs	222	222	222	127	127	37
Solar Pool Heating	3,889	3,889	3,889	2,511	2,511	674
Refrigeration						
Commercial Ice-makers	26,532	0	0	0	0	0
Commercial Refrigerators/Freezers	93,160	93,160	58,023	51,181	31,879	14,740
Door Heater Controls	358,316	358,316	358,316	201,090	201,090	53,970
Efficient compressors/condensers	41,764	39,296	39,296	15,810	15,810	4,553
Fan motors & controls	1,073,482	1,068,494	1,060,703	588,324	583,523	162,134

End Use	Technical Potential (MWh)	Economic UCT (MWh)	Economic TRC (MWh)	Achievable UCT (MWh)	Achievable TRC (MWh)	Constrained Achievable (MWh)
Floating Head Pressure Control	79,686	79,686	79,686	52,245	52,245	14,022
Refrigerated Case Covers	22,698	22,698	22,698	14,993	14,993	4,861
Refrigeration Economizer, Refrigerant charging correction	15,932	1,715	1,745	1,133	1,152	366
Refrigeration Savings due to Lighting Savings	14,624	14,624	14,624	8,050	8,050	2,318
Refrigerator/Freezer Door Modifications	1,537,397	1,537,397	1,537,397	883,813	883,813	272,963
Vending Miser for Soft Drink Vending Machines	215,245	215,245	215,245	141,757	141,757	38,046
Space Cooling						
Air-Cooled and Water-Cooled Chillers	72,219	72,219	72,219	15,502	15,502	4,465
Chilled Hot Water Reset	122,109	122,109	122,109	75,171	75,171	20,993
Ductless/GSHP/PTAC/WLHP	154,077	5,269	4,840	1,902	1,747	548
High Efficiency AC - Unitary & Split Systems	27,415	27,415	27,415	9,897	9,897	2,850
High Efficiency Pumps	50,886	50,886	50,886	9,685	9,685	2,599
Space Heating						
Ductless/ASHP / GSHP/PTAC/WLHP Systems	226,055	145,590	24,686	77,347	7,565	20,907
ECM motors on furnaces	8,496	8,496	8,496	1,617	1,617	434
High Efficiency Pumps / VFD's on Pumps	22,298	22,298	22,298	10,775	10,775	2,900
Ventilation						
Controlled Ventilation Optimization, Enthalpy Economizer, Improved Duct Sealing	1,395,267	1,134,696	888,449	466,907	380,498	134,467
Destratification Fan	28,152	0	0	0	0	0
Electronically-Commutated Permanent Magnet Motors (ECPMs)	170,724	170,724	170,724	68,995	68,995	19,870
High Performance Air Filters	554,183	554,183	554,183	63,142	63,142	20,467
Variable Speed Drive Control	604,438	604,438	604,438	364,084	364,084	97,716
Water Heating						
Booster Water Heater	6,783	0	0	0	0	0
Clothes Washer/Ozone Commercial Laundry	2,969	1,055	1,711	462	898	142
Dishwasher	3,509	3,509	3,509	1,289	1,289	371

END USE	TECHNICAL POTENTIAL (MWH)	ECONOMIC UCT (MWH)	ECONOMIC TRC (MWH)	ACHIEVABLE UCT (MWH)	ACHIEVABLE TRC (MWH)	CONSTRAINED ACHIEVABLE (MWH)
Efficient Hot Water Pump	30,449	30,449	30,449	9,553	9,553	2,564
Heat Pump Water Heater	69,588	69,588	69,588	30,662	30,662	8,830
Drainwater / Heat Recovery	4,946	4,946	0	3,048	0	824
High Efficiency Electric Water Heater	18,579	18,579	18,579	9,428	9,428	2,715
Insulation	128,833	128,833	128,833	84,797	84,797	22,758
Low Flow Measures	77,391	77,391	77,391	28,186	28,186	7,679
Hot Water Circulation Pump Time-Clock	443	443	443	205	205	55
Point of Use Water Heating	1,506	0	0	0	0	0
Solar Water Heating System	7,486	7,486	7,486	4,267	4,267	1,145
Total	**18,601,147**	**17,251,862**	**14,344,326**	**8,057,699**	**6,835,102**	**2,326,054**
% of Annual Sales Forecast	**47.95%**	**44.48%**	**36.98%**	**20.77%**	**17.62%**	**6.00%**
Note: Measures in the above Table with "0" achievable potential are ones that did not pass the SCT Test.						

Table 7-21 provides a list of the Top 10 commercial electric savings measures for the Achievable UCT scenario. The table provides the measures ranked according to the electric savings potential. The column to the far right shows the results of the measure level cost-effectiveness screening test using the UCT to screen the measures. The measures in the table are representative of a group of comparable measures falling under the umbrella of the measure categories provided in the table. This means that there are a range of UCT ratios for measure iterations that fall into a single measure category. For example, "Specialty LED Bulbs" is a measure category which consists of several measure iterations to account for bulb type and wattage and housing type. The table presents an average of the UCT ratios for all measures which are part of the measure categories in the Top 10.

The Top 10 commercial sector energy efficiency measures combine to yield an estimated 6.2 million MWh savings. This accounts for 77% of the total commercial electric savings in the Achievable UCT scenario.

Table 7-21: Top 10 Commercial Sector Electric Savings Measures in the Achievable UCT Scenario by 2023

MEASURE	2023 ENERGY (MWH)	% OF SECTOR SAVINGS	UCT RATIO
Lighting Controls and Design	2,125,176	26.4%	9.2
Refrigerator/Freezer Door Modifications	883,813	11.0%	4.0
Fluorescent Tube Lighting Efficiency	802,591	10.0%	2.3
Fan motors & controls	588,324	7.3%	6.9
Controlled Ventilation Optimization, Enthalpy Economizer, Improved Duct Sealing	466,907	5.8%	1.8
Variable Speed Drive Control	364,084	4.5%	2.6
Office Equipment / Appliances	318,165	3.9%	10.7
LED Lighting Efficiency	255,499	3.2%	5.4
CFL Lighting Efficiency	216,558	2.7%	16.6
Door Heater Controls	201,090	2.5%	4.8
Total	**6,222,205**	**77.2%**	**6.5**

7.2 COMMERCIAL SECTOR NATURAL GAS ENERGY EFFICIENCY POTENTIAL

The GDS Associates natural gas consumption forecasts for the residential, commercial and industrial segments of the Michigan economy indicates that annual natural gas use will decrease by about 10% from 669.2 trillion BTU in 2013 to 603.2 trillion BTU in 2023.[43] Over that same period commercial natural gas use is expected to remain relatively stable varying annually between a range of 168.4 trillion BTU and 172.0 trillion BTU.

7.2.1 Natural Gas Energy Efficiency Measures Examined

For the commercial sector, there were 86 unique natural gas energy efficiency measures included in the potential gas savings analysis. Table 7-22 provides a brief description of the types of natural gas energy efficiency measures included for each end use in the commercial sector. The list of measures was developed based on a review of the Michigan Energy Measures Database (MEMD), and measures found in other Technical Reference Manuals (TRMs) and measures listed in other commercial sector energy efficiency

[43] GDS applied a forecast trends to actual deliveries by customer classes as reported by the U.S. Energy Information Administration (EIA). The annual sales forecast trends are based the EAI's Long term Reference Case forecast of natural gas consumption for the East North Central Region (Illinois, Indiana, Michigan, Ohio, and Wisconsin) as reported in the EIA 2013 Annual Energy Outlook.

potential studies. For each measure, the analysis considered incremental costs, energy and demand savings, and useful measure life.

Table 7-22: Natural Gas Energy Efficiency Measures and Programs Included in the Commercial Sector Analysis

END USE TYPE	END USE DESCRIPTION	MEASURES INCLUDED
Building Envelope	Space Heating	• Building Envelope Improvements • Integrated Building Design
Cooking	Cooking Equipment Improvements	• Efficient Cooking Equipment
HVAC Controls	Space Heating	• EMS Installation/Optimization • Zoning • Commissioning & Retrocommissioning • Programmable Thermostats
Space Heating	Heating System Improvements	• Efficient Heating Equipment • Improved Duct Sealing • Pipe and Tank Insulation • Heating System Controls & Tune-up • Boiler Upgrades • Steam Trap Repair • Destratification Fans • Ventilation Controls • Heat Recovery • Thermostat Upgrades and Controls • Energy Recovery Ventilator
Space & Water Heating	Equipment Improvements	• High Efficiency Combined Space and Water Heating Equipment
Water Heating	Water Heating Improvements	• Efficient Water Heating Equipment • Heat Recovery Systems • Pipe Insulation & Pool Covers • Low Flow Equipment • Water Heater Controls & Tune-ups • Solar Water Heating System • Ozone Laundry System • Efficient Pool Heaters • Solar Pool Water Heater • Efficient HW Appliances

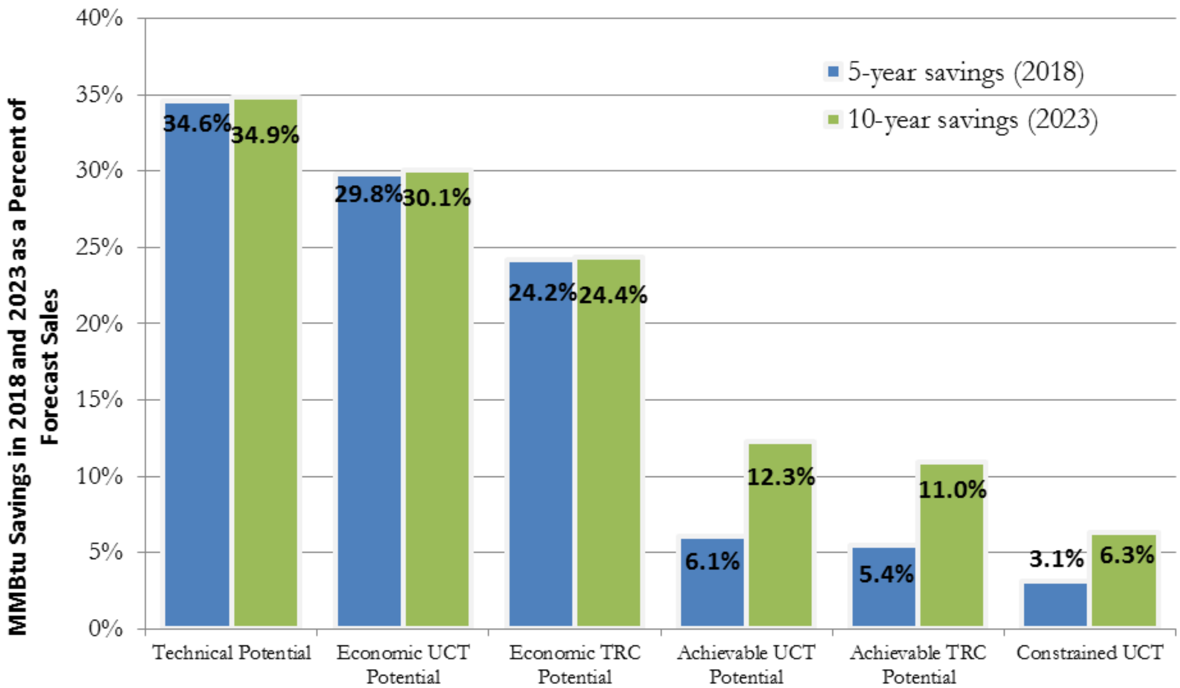
7.2.2 Technical and Economic Potential Natural Gas Savings

This section presents estimates for natural gas energy efficiency technical, economic, and achievable potential for the commercial sector (commercial and institutional combined). Each of the tables in the technical, economic and achievable sections present the respective potential for energy efficiency savings expressed as cumulative annual savings (MMBtu) and percentage of forecast annual natural gas sales for the commercial sector. Data is provided for a 5 and 10-year horizon for Michigan.

SUMMARY OF FINDINGS

Figure 7-4 illustrates the estimated energy efficiency savings potential for each of all the scenarios included in this study.

Figure 7-4: Summary of Commercial Natural Gas Energy Efficiency Potential as a % Sales Forecasts



The potential estimates are expressed as cumulative annual 5-year and 10-year savings, as percentages of the respective 2018 and 2023 commercial sector natural gas sales forecasts. The technical potential is 34.6% in 2018 and 34.9% in 2023. The 5-year and 10-year economic potential is 29.8% and 30.1% based on the Utility Cost Test (UCT) screen, assuming an incentive level equal to 50% of the measure cost. Based on a measure-level screen using the TRC Test, the economic potential is 24.2% in 2018 and 24.4% in 2023. The slight drop from technical potential to economic potential indicates that most measures are cost-effective.

The 5-year and 10-year achievable potential savings are: 6.1% and 12.3% for the Achievable UCT scenario; 5.4% and 11.0% for the Achievable TRC scenario; and 3.1% and 6.3% for the Constrained Achievable scenario. The Achievable UCT scenario assumes 50% incentives and includes measures that passed the UCT Test. The Achievable TRC scenario also assumes 50% incentives but includes only measures that passed the cost-effectiveness screen based on the TRC Test. Last, the Constrained Achievable scenario is a subset of Achievable UCT scenario, assuming a spending cap on non-residential DSM approximately equal to 2% of future annual commercial and industrial revenue. The percent of the non-residential spending cap allocated to the commercial sector is based on the percentage of total non-residential UCT savings that the commercial sector represents. This presumes that the total non-residential spending cap will be allocated at the sector level based on where the savings opportunities are found.

TECHNICAL POTENTIAL

Technical potential represents the quantification of savings that can be realized if energy-efficiency measures passing the qualitative screening are applied in all feasible instances, regardless of cost or cost effectiveness. Table 7-23 shows that it is technically feasible to save nearly 58.9 million MMBtu (on a cumulative annual basis) in the commercial sector between 2014 and 2018 and approximately 59 million MMBtu during the 10 year period from 2014 to 2023 across Michigan, representing approximately 34.6% of the commercial sales forecast for 2018, and 34.9% of 10-year commercial sales forecast. HVAC Controls and Space Heating energy efficiency measures represent the majority of the potential at 36% and 27% of 10-yr savings, respectively, while cooking and space and water heating energy efficiency measures represent the smallest share each with 6% and 0.1% of 10-yr savings respectively.

Table 7-23: Commercial Sector Natural Gas Technical Potential MMBtu Savings by End Use

END USE	2018 ENERGY SAVINGS (MMBTU)	% OF 2018 TOTAL	2023 ENERGY SAVINGS (MMBTU)	% OF 2023 TOTAL
Space Heating	15,624,610	27%	15,667,637	27%
Building Envelope	8,008,290	14%	8,008,290	14%
Water Heating	10,914,990	19%	10,945,006	19%
HVAC Controls	21,055,539	36%	21,116,594	36%
Space & Water Heating	49,645	0.1%	49,781	0.1%
Cooking	3,261,157	6%	3,270,105	6%
Lighting	-9,838	0.0%	-9,840	0.0%
Total	**58,904,392**	**100%**	**59,047,573**	**100%**
Percent of Annual Sales Forecast	*34.6%*		*34.9%*	

ECONOMIC POTENTIAL

Economic potential is a subset of technical potential only includes measures that are cost-effective. This analysis includes two estimates of economic potential. One cost-effectiveness screen is based on the UCT and a second economic potential scenario was screened using the TRC Test. In both scenarios, the utility incentive was assumed to be equal to 50% of the measure incremental cost. The UCT was used for this study because it is mandated in Michigan to be the primary cost-effectiveness test used when considering energy efficiency programs. Because the TRC includes participant costs as well as all utility costs, it goes beyond utility resource acquisition and looks at the measure/program from a broader perspective. 75% of all measures that were included in the natural gas potential analysis passed the UCT and 63% of all measures passed the TRC Test.

Table 7-24 indicates that the economic potential based on the UCT screen is more than 50.7 million MMBtu by 2018, and the economic potential increases to 50.9 million MMBtu by 2023. This represents 29.8% and 30.1% of commercial sales across the respective 5-year and 10-year timeframes. The HVAC Controls measures make up a majority of the savings, followed by Space Heating.

Table 7-24: Commercial Sector Economic Natural Gas UCT Savings by End Use

END USE	2018 ENERGY SAVINGS (MMBTU)	% OF 2018 TOTAL	2023 ENERGY SAVINGS (MMBTU)	% OF 2023 TOTAL
Space Heating	13,752,800	27%	13,790,393	27%
Building Envelope	5,636,708	11%	5,710,915	11%
Water Heating	7,883,447	16%	7,905,197	16%
HVAC Controls	20,675,963	41%	20,724,787	41%
Space & Water Heating	49,645	0%	49,781	0%
Cooking	2,770,955	5%	2,778,558	5%
Lighting	-9,516	0%	-9,518	0%
Total	**50,760,002**	**100%**	**50,950,115**	**100%**
Percent of Annual Sales Forecast	*29.8%*		*30.1%*	

Table 7-25 shows that the economic potential based on the TRC screen is more than 41.1 million MMBtu during the 5 year period from 2014 to 2018, and the economic potential increases slightly to 41.3 million MMBtu during the 10 year period from 2014 to 2023. This represents 24.2% and 24.4% of commercial sales across the respective 5-year and 10-year timeframes. Again Space Heating and HVAC Controls make up the majority of the Economic TRC savings with HVAC Controls representing the largest economic TRC potential.

Table 7-25: Commercial Sector Economic Natural Gas TRC Savings by End Use

END USE	2018 ENERGY SAVINGS (MMBTU)	% OF 2018 TOTAL	2023 ENERGY SAVINGS (MMBTU)	% OF 2023 TOTAL
Space Heating	13,287,678	32%	13,324,269	32%
Building Envelope	2,098,196	5%	2,098,196	5%
Water Heating	6,219,338	15%	6,236,441	15%
HVAC Controls	18,088,560	44%	18,141,011	44%
Space & Water Heating	49,645	0%	49,781	0%
Cooking	1,450,344	4%	1,454,324	4%
Lighting	-5,585	0%	-5,587	0%
Total	**41,188,176**	**100%**	**41,298,436**	**100%**
Percent of Annual Sales Forecast	*24.2%*		*24.4%*	

7.2.3 Achievable Potential Savings in the Commercial Sector

Achievable potential is an estimate of energy savings that can feasibly be achieved given market barriers and equipment replacement cycles. This study estimated achievable potential for three scenarios. The Achievable UCT Scenario determines the achievable potential of all measures that passed the UCT economic screening assuming incentives equal to 50% of the measure cost. Unlike the economic potential, the commercial achievable potential takes into account the estimated market adoption of energy efficiency measures based on the incentive level and the natural replacement cycle of equipment. The second scenario, Achievable TRC, also assumes incentives set at 50% of the measure incremental cost, but only includes measures that passed the TRC Test economic screening. The third scenario, Constrained UCT, assumes a spending cap equal to 2% of utility revenues, thereby limiting utilities from reaching the ultimate potential estimated in the Achievable UCT scenario.

7.2.3.1 UCT vs. TRC

Tables 7-26 and 7-27 show the estimated savings for the Achievable UCT and Achievable TRC scenarios over 5 and 10 year time horizons. As noted above, both scenarios assume an incentive level approximately equal to 50% of the incremental measure cost and include an estimate 10-year market adoption rates based on incentive levels and equipment replacement cycles. However, because more measures pass the UCT relative to the TRC Test, the Achievable UCT scenario is able to include additional measures that would result in greater savings potential over the next five and ten years. Overall the Achievable UCT scenario results in an achievable potential that is 2.2 MMBtu greater, over the next decade, than the achievable TRC scenario.

Table 7-26: Commercial Achievable UCT Natural Gas Potential Savings by End Use

END USE	2018 ENERGY SAVINGS (MMBTU)	% OF 2018 TOTAL	2023 ENERGY SAVINGS (MMBTU)	% OF 2023 TOTAL
Space Heating	2,527,332	24%	5,083,771	24%
Building Envelope	235,323	2%	470,646	2%
Water Heating	1,409,729	14%	2,812,285	14%
HVAC Controls	5,438,920	52%	10,848,733	52%

END USE	2018 ENERGY SAVINGS (MMBTU)	% OF 2018 TOTAL	2023 ENERGY SAVINGS (MMBTU)	% OF 2023 TOTAL
Space & Water Heating	12,262	0%	24,525	0%
Cooking	760,904	7%	1,528,979	7%
Lighting	-1,533	0%	-2,846	0%
Total	**10,382,936**	**100%**	**20,766,093**	**100%**
Percent of Annual Sales Forecast	*6.1%*		*12.3%*	

Table 7-27: Commercial Achievable TRC Natural Gas Potential Savings by End Use

END USE	2018 ENERGY SAVINGS (MMBTU)	% OF 2018 TOTAL	2023 ENERGY SAVINGS (MMBTU)	% OF 2023 TOTAL
Space Heating	2,397,548	26%	4,795,096	26%
Building Envelope	81,778	1%	163,556	1%
Water Heating	1,131,606	12%	2,263,213	12%
HVAC Controls	5,260,279	57%	10,520,558	57%
Space & Water Heating	12,262	0%	24,525	0%
Cooking	391,666	4%	783,332	4%
Lighting	-760	0%	-1,520	0%
Total	**9,274,379**	**100%**	**18,548,759**	**100%**
Percent of Annual Sales Forecast	*5.4%*		*11.0%*	

7.2.3.2 Achievable UCT vs. Constrained UCT

Although the Achievable UCT assumes incentives are set and capped at 50% of the incremental measure cost, and that measures are typically replaced at the end of their useful life, the Achievable UCT scenario also assumes no DSM spending cap to reach all potential participants. In the Constrained UCT scenario, the analysis assumes a spending cap roughly equal to 2% of Michigan annual natural gas utility revenue. The percent of the non-residential spending cap allocated to the commercial sector is based on the percentage of total non-residential UCT savings that the commercial sector represents. This presumes that the total non-residential spending cap will be allocated at the sector level based on where the savings opportunities are found. To model the impact of a spending cap the market penetration of all cost effective measures was reduced by the ratio of capped spending to uncapped spending that would be required to achieve the Achievable UCT scenario savings potential.

Table 7-28 shows the estimated savings for the Constrained UCT scenario over 5 and 10 year time horizons. The 5-year and 10-year Constrained UCT potential savings estimates are approximately 5.3 million MMBtu and 10.7 million MMBtu. This equates to 3.1% and 6.3% of commercial sector natural gas sales in 2018 and 2023.

Table 7-28: Commercial Constrained UCT Natural Gas Achievable Energy Savings by End Use

END USE	2018 ENERGY SAVINGS (MMBTU)	% OF 2018 TOTAL	2023 ENERGY SAVINGS (MMBTU)	% OF 2023 TOTAL
Space Heating	1,292,370	24%	2,613,597	24%
Building Envelope	120,334	2%	243,240	2%
Water Heating	720,875	14%	1,457,290	14%
HVAC Controls	2,781,233	52%	5,630,643	52%
Space & Water Heating	6,270	0%	12,675	0%
Cooking	389,094	7%	786,784	7%
Lighting	-397	0%	-814	0%
Total	**5,309,780**	**100%**	**10,743,415**	**100%**
Percent of Annual Sales Forecast	*3.1%*		*6.3%*	

Figure 7-5 shows the estimated 10-year cumulative natural gas energy efficiency savings potential broken out by end use across the entire commercial sector. HVAC Controls show the largest potential for savings at 5.6 million MMBtu, or 52% of total savings, in the Constrained UCT Achievable scenario.

Figure 7-5: Commercial Sector 2023 Constrained UCT Achievable Potential Natural Gas Savings by End Use

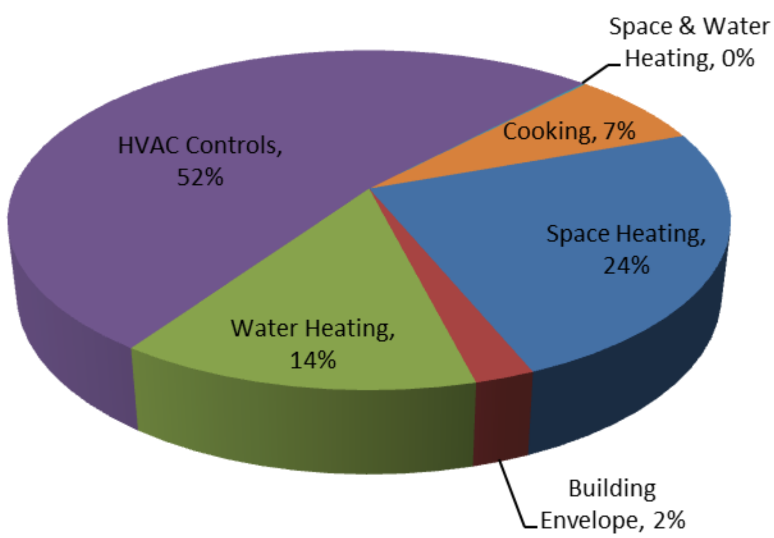
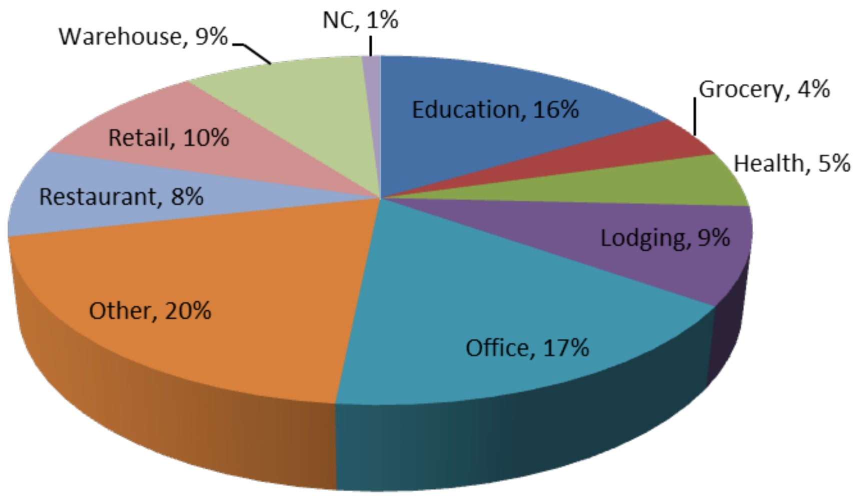


Figure 7-6 shows the breakdown of estimated natural gas savings in 2023 by building type for the Constrained UCT Achievable scenario. The vast majority of savings come from existing/turnover measures, meaning energy efficient equipment is installed in replacement of existing equipment that has failed, with about 1% of savings potential coming from new construction. The 'Offices' and 'Other' categories represent the largest potential savings at 17% and 20% respectively.

Figure 7-6: Commercial Constrained UCT Achievable Natural gas Potential Savings in 2023 by Building Type



7.2.4 Annual Achievable Natural Gas Savings Potential

Tables 7-29, Table 7-30 and Table 7-31 show cumulative energy savings for all achievable scenarios for each year across the 10-year horizon for the study, broken out by end use.

Table 7-29: Cumulative Annual Commercial Natural Gas Savings in the Achievable UCT Potential Scenario, by End Use for Michigan

END USE	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Space Heating	505,466	1,010,933	1,516,399	2,021,866	2,527,332	3,032,798	3,538,265	4,043,731	4,549,198	5,054,664
Building Envelope	47,065	94,129	141,194	188,258	235,323	282,387	329,452	376,516	423,581	470,646
Water Heating	281,946	563,891	845,837	1,127,783	1,409,729	1,691,674	1,973,620	2,255,566	2,537,511	2,819,457
HVAC Controls	1,087,784	2,175,568	3,263,352	4,351,136	5,438,920	6,526,704	7,614,488	8,702,272	9,790,056	10,877,840
Space & Water Heating	2,452	4,905	7,357	9,810	12,262	14,715	17,167	19,620	22,072	24,525
Cooking	152,181	304,361	456,542	608,723	760,904	913,084	1,065,265	1,217,446	1,369,627	1,521,807
Lighting	-373	-746	-1,008	-1,271	-1,533	-1,796	-2,059	-2,321	-2,584	-2,846
Total	**2,076,521**	**4,153,042**	**6,229,673**	**8,306,305**	**10,382,936**	**12,459,567**	**14,536,199**	**16,612,830**	**18,689,461**	**20,766,093**
% of Annual Sales Forecast	*1.2%*	*2.4%*	*3.6%*	*4.8%*	*6.1%*	*7.3%*	*8.6%*	*9.8%*	*11.0%*	*12.3%*

Table 7-30: Cumulative Annual Commercial Natural Gas Savings in the Achievable TRC Potential Scenario, by End Use for Michigan

END USE	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Space Heating	479,510	959,019	1,438,529	1,918,038	2,397,548	2,877,057	3,356,567	3,836,076	4,315,586	4,795,096
Building Envelope	16,356	32,711	49,067	65,422	81,778	98,133	114,489	130,845	147,200	163,556
Water Heating	226,321	452,643	678,964	905,285	1,131,606	1,357,928	1,584,249	1,810,570	2,036,891	2,263,213
HVAC Controls	1,052,056	2,104,112	3,156,167	4,208,223	5,260,279	6,312,335	7,364,390	8,416,446	9,468,502	10,520,558
Space & Water Heating	2,452	4,905	7,357	9,810	12,262	14,715	17,167	19,620	22,072	24,525
Cooking	78,333	156,666	235,000	313,333	391,666	469,999	548,333	626,666	704,999	783,332
Lighting	-152	-304	-456	-608	-760	-912	-1,064	-1,216	-1,368	-1,520
Total	**1,854,876**	**3,709,752**	**5,564,628**	**7,419,504**	**9,274,379**	**11,129,255**	**12,984,131**	**14,839,007**	**16,693,883**	**18,548,759**
% of Annual Sales Forecast	*1.1%*	*2.2%*	*3.2%*	*4.3%*	*5.4%*	*6.5%*	*7.7%*	*8.8%*	*9.9%*	*11.0%*

Table 7-31: Cumulative Annual Commercial Natural Gas Savings in Constrained Achievable Potential Scenario by End Use for Michigan

END USE	2014	2015	2016	2017	2018	2018	2019	2020	2021	2023
Space Heating	256,489	510,744	767,133	1,027,653	1,292,370	1,560,633	1,833,429	2,095,955	2,354,082	2,613,597
Building Envelope	23,882	47,556	71,429	95,686	120,334	145,277	170,622	195,048	219,082	243,240
Water Heating	143,068	284,890	427,901	573,218	720,875	870,354	1,022,272	1,168,626	1,312,597	1,457,290
HVAC Controls	551,975	1,099,142	1,650,900	2,211,550	2,781,233	3,357,730	3,943,517	4,511,471	5,069,239	5,630,643
Space & Water Heating	1,244	2,478	3,722	4,986	6,270	7,570	8,891	10,164	11,416	12,675
Cooking	77,221	153,770	230,961	309,395	389,094	469,746	551,697	630,805	708,605	786,784
Lighting	-107	-195	-257	-320	-397	-474	-559	-644	-728	-814
Total	**1,053,773**	**2,098,385**	**3,151,789**	**4,222,167**	**5,309,780**	**6,410,836**	**7,529,869**	**8,611,423**	**9,674,293**	**10,743,415**
% of Annual Sales Forecast	*0.6%*	*1.2%*	*1.8%*	*2.5%*	*3.1%*	*3.8%*	*4.4%*	*5.1%*	*5.7%*	*6.3%*

7.2.5 Commercial Savings Summary

Table 7-32 provides an end-use breakdown of the commercial natural gas savings potential estimates for technical and economic potential, and each of the three achievable potential scenarios. The table indicates how the savings potential decreases systematically from the technical potential scenario to the Constrained Achievable potential scenario as additional limiting factors such as cost-effectiveness requirements and anticipated market adoption at given funding levels are introduced.

Table 7-32: Cumulative Annual Natural Gas Potential by End-Use and Measure by 2023

END USE	TECHNICAL POTENTIAL (MMBTU)	ECONOMIC POTENTIAL -UCT- (MMBTU)	ECONOMIC POTENTIAL -TRC- (MMBTU)	ACHIEVABLE POTENTIAL -UCT- (MMBTU)	ACHIEVABLE POTENTIAL -TRC- (MMBTU)	CONSTRAINED ACHIEVABLE –UCT- (MMBTU)
Building Envelope						
Energy Efficient Windows	2,527,092	2,606,377	0	65,610	0	33,909
Greenhouse Curtains/Film	2,134,571	157,031	157,031	0	0	0
Insulation Upgrades	2,860,091	2,799,094	1,941,166	313,101	163,556	161,817
Integrated Building Design	148,413	148,413	0	91,935	0	47,514
Truck Loading Dock Seals	338,123	0	0	0	0	0
Space Heating						
Boiler Modifications/Controls	2,024,237	1,289,152	1,204,178	501,466	478,001	260,085
Condensing Boiler & Efficiency Improvements	968,985	0	0	0	0	0
Demand Controlled Ventilation	5,798,651	5,798,651	5,798,651	2,345,939	2,345,939	1,212,432
Destratification Fans	2,030,198	2,030,198	2,030,198	799,636	799,636	413,269
Gas Furnace	1,003,319	1,003,319	1,003,319	373,864	373,864	193,221
Gas Unit Heater	534,530	534,530	534,530	162,375	162,375	83,919
Guest Room Energy Management	414,392	381,149	0	236,103	0	122,342
Heat Recovery/ERV	139,932	0	0	0	0	0
Infrared Heater	107,083	107,083	107,083	18,120	18,120	9,365
Makeup Air	1,215,491	1,215,491	1,215,491	332,415	332,415	171,799
Pipe Insulation/Duct Sealing	1,261,180	1,261,180	1,261,180	284,746	284,746	147,163
Tune-up/Steam Trap Repair	169,638	169,638	169,638	0	0	0
HVAC Controls						
Commissioning/Retrocommissioning	4,766,120	4,766,147	4,773,400	2,952,390	2,956,883	1,533,321
EMS Install/Optimization	9,627,692	9,235,859	9,235,859	5,382,715	5,382,715	2,781,905
Programmable Thermostat	4,131,752	4,131,752	4,131,752	2,180,960	2,180,960	1,128,444
Zoning	2,591,030	2,591,030	0	361,775	0	186,973

END USE	TECHNICAL POTENTIAL (MMBTU)	ECONOMIC POTENTIAL -UCT- (MMBTU)	ECONOMIC POTENTIAL -TRC- (MMBTU)	ACHIEVABLE POTENTIAL -UCT- (MMBTU)	ACHIEVABLE POTENTIAL -TRC- (MMBTU)	CONSTRAINED ACHIEVABLE –UCT- (MMBTU)
Cooking						
High Efficiency Fryer	876,851	719,773	0	476,733	0	246,386
High Efficiency Gas Broiler	93,600	69,879	0	50,889	0	26,301
High Efficiency Gas Ovens	588,015	266,094	109,725	161,582	61,761	83,509
High Efficiency Gas Griddle	214,275	0	0	0	0	0
High Efficiency Gas Steamer	1,327,180	1,327,180	1,327,180	721,571	721,571	372,924
Power Burner Range	170,183	142,194	0	111,031	0	57,664
Water Heating						
Circulation Pump Time Clocks	749,404	749,404	749,404	346,537	346,537	179,098
Clothes Washer ENERGY STAR	306,521	0	100,427	0	60,087	0
Stand Alone Commercial Water Heaters	541,885	159,327	159,327	63,436	63,436	32,785
ES Dishwasher	489,713	489,713	489,713	179,857	179,857	92,954
Heat Recovery Water Heater/GFX	1,537,068	1,537,068	909,492	620,335	408,781	320,603
Indirect Water Heaters	451,984	451,984	0	174,093	0	89,975
Low Flow Aerators/Showerheads/Nozzles	973,772	973,772	973,772	73,273	73,273	38,002
On-Demand, Tankless Water Heater	1,901,498	933,988	726,976	310,415	241,614	160,429
Ozone Laundry System/Generator	776,210	776,210	776,210	344,634	344,634	178,114
Pipe wrap/Tune-up	714,609	219,165	219,165	71,576	71,576	36,992
Pool Measures (including Solar)	1,131,955	1,131,955	1,131,955	473,418	473,418	244,673
Solar Water Heating	887,777	0	0	0	0	0
Wastewater, Filtration/Reclamation	482,611	482,611	0	161,884	0	83,665
Space & Water Heating						
Combination Water Heater/Boiler	45,063	45,063	45,063	24,525	24,525	12,675
Combination Water Heater/Furnace	4,718	4,718	4,718	0	0	0

END USE	TECHNICAL POTENTIAL (MMBTU)	ECONOMIC POTENTIAL -UCT- (MMBTU)	ECONOMIC POTENTIAL -TRC- (MMBTU)	ACHIEVABLE POTENTIAL -UCT- (MMBTU)	ACHIEVABLE POTENTIAL -TRC- (MMBTU)	CONSTRAINED ACHIEVABLE –UCT- (MMBTU)
Lighting						
Lighting	-9,840	-9,518	-5,587	-2,846	-1,520	-814
Total	**59,047,573**	**50,950,115**	**41,298,436**	**20,766,093**	**18,548,759**	**10,743,415**
% of Annual Sales Forecast	**34.9%**	**30.1%**	**24.4%**	**12.3%**	**11.0%**	**6.3%**
Note: Measures in the Table with "0" in the Economic or Achievable Potentials are ones that did not pass the TRC or UCT.						

Table 7-33 provides a list of the Top 10 commercial natural gas savings measures for the Achievable UCT scenario. The table provides the measures ranked highest to lowest according to the cumulative annual natural gas savings potential. The column to the far right shows the results of the measure level cost-effectiveness screening test using the UCT to screen the measures. The measures in the table are representative of a group of comparable measures falling under the umbrella of the measure categories provided in the table. This means that there are a range of UCT ratios for measure iterations that fall into a single measure category. For example, "Heat Recovery Water Heater/GFX" is a measure category which consists of water heater recovery systems including gray water heat exchangers. The table presents an average of the UCT ratios for all measures which are part of the measure categories in the Top 10.

The Top 10 measures combine to yield an estimated 16,400,000 MMBtu savings. This accounts for 79.2% of the total commercial gas savings in the Achievable UCT scenario.

Table 7-33: Top 10 Commercial Natural Gas Savings Measures in the Achievable UCT Scenario

MEASURE	2023 ENERGY (MMBTU)	% OF SECTOR SAVINGS	UCT RATIO
EMS install/Optimization	5,382,715	25.9%	42.6
Commissioning/Retrocommissioning	2,952,390	14.2%	8.1
Demand Controlled Ventilation	2,345,939	11.3%	24.7
Programmable Thermostat	2,180,960	10.5%	33.7
Destratification Fans	799,636	3.9%	2.3
High Efficiency Gas Steamer	721,571	3.5%	2.7
Heat Recovery Water Heater/GFX	620,335	3.0%	3.4
Boiler Modifications/Controls	501,466	2.4%	2.1
High Efficiency Fryer	476,733	2.3%	1.3
Pool Measures (including Solar)	473,418	2.3%	4.0
Total	**16,455,163**	**79.2%**	**12.5**

7.3 ACHIEVABLE POTENTIAL BENEFITS & COSTS

The tables below provide the net present value (NPV) benefits and costs associated with the three achievable potential scenarios for the commercial sector at the 5-year and 10-year periods. Tables 7-34 and 7-35 compare the 5 and 10 year NPV benefits and costs associated with the Achievable UCT and Achievable TRC Scenarios. Both the UCT and TRC scenario benefits include avoided energy supply and demand costs, while the Achievable TRC scenario benefits also include water savings benefits, and carbon tax adder. The NPV costs in the Achievable UCT scenario includes only program administrator costs (incentives paid, staff labor, marketing, etc.) whereas the Achievable TRC scenario costs include both participant and program administrator costs.

Table 7-34: 5-Year Benefit-Cost Ratios for Achievable Potential Scenarios – Commercial Sector Only

5-YEAR	NPV BENEFITS	NPV COSTS	B/C RATIO	NET BENEFITS
Achievable UCT	$3,926,211,328	$1,514,585,402	2.59	$ 2,411,625,926
Achievable TRC	$3,590,040,097	$1,331,359,508	2.70	$ 2,258,680,589

Table 7-35: 10-Year Benefit-Cost Ratios for Achievable Potential Scenarios– Commercial Sector Only

10-YEAR	NPV BENEFITS	NPV COSTS	B/C RATIO	NET BENEFITS
Achievable UCT	$7,120,951,471	$2,506,173,980	2.84	$ 4,614,777,491
Achievable TRC	$6,556,350,912	$2,235,299,451	2.93	$ 4,321,051,461

Tables 7-36 and 7-37 compare the NPV benefits and costs associated with the Achievable UCT and Constrained UCT Scenarios. Both scenarios compared the benefits and costs based the UCT. However the constrained scenario's 2% of revenue spending cap on DSM results in reduced program participation and overall NPV benefits.

Table 7-36: 5-Year Benefit-Cost Ratios for Achievable Potential Scenarios – Commercial Sector Only

5-YEAR	NPV BENEFITS	NPV COSTS	B/C RATIO	NET BENEFITS
Achievable UCT	$3,926,211,328	$1,514,585,402	2.59	$ 2,411,625,926
Constrained UCT	$1,111,987,608	$422,340,965	2.63	$ 689,646,644

Table 7-37: 10-Year Benefit-Cost Ratios for Achievable Potential Scenarios– Commercial Sector Only

10-YEAR	NPV BENEFITS	NPV COSTS	B/C RATIO	NET BENEFITS
Achievable UCT	$7,120,951,471	$2,506,173,980	2.84	$ 4,614,777,491
Constrained UCT	$2,196,078,237	$757,273,804	2.90	$ 1,438,804,433

Year by year budgets for all three scenarios, broken out by incentive and administrative costs are presented in Tables 7-38 through 7-40. Table 7-41 shows the revenue requirements for each scenario as a percentage of forecasted sector sales.

Table 7-38: Year By Year Budgets for Achievable Potential TRC Scenarios– Commercial Sector Only (Millions of Dollars)

	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Admin	$ 39.7	$ 52.1	$ 56.6	$ 56.6	$ 46.5	$ 48.3	$ 43.7	$ 45.0	$ 47.5	$ 47.5
Incentive	$ 99.2	$130.2	$141.5	$141.6	$116.3	$120.7	$109.2	$112.4	$118.7	$118.8
Total	$138.8	$182.3	$198.1	$198.2	$162.8	$168.9	$152.9	$157.3	$166.2	$166.3

Table 7-39: Year By Year Budgets for Achievable Potential UCT Scenarios– Commercial Sector Only (Millions of Dollars)

	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Admin	$ 85.7	$103.9	$105.0	$105.0	$ 89.1	$ 91.0	$ 83.8	$ 85.2	$ 88.0	$ 87.7
Incentive	$214.2	$259.7	$262.5	$262.6	$222.7	$227.5	$209.5	$212.9	$220.0	$219.3
Total	$299.8	$363.6	$367.5	$367.6	$311.8	$318.5	$293.3	$298.1	$308.0	$307.0

Table 7-40: Year By Year Budgets for Cost Constrained UCT Scenarios– Commercial Sector Only (Millions of Dollars)

	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Admin	$ 26.5	$ 26.8	$ 27.2	$ 27.7	$ 28.1	$ 28.6	$ 29.0	$ 29.5	$ 30.0	$ 30.4
Incentive	$ 66.3	$ 66.9	$ 68.1	$ 69.2	$ 70.3	$ 71.4	$ 72.6	$ 73.7	$ 74.9	$ 76.1
Total	$ 92.8	$ 93.7	$ 95.4	$ 96.9	$ 98.4	$ 100.0	$101.6	$103.2	$104.9	$106.5

Table 7-41: Utility Energy Efficiency Budgets per Scenario as a % of Sector Revenues

	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Achievable UCT	6.5%	7.9%	7.8%	7.7%	6.4%	6.4%	5.8%	5.8%	5.9%	5.8%
Achievable TRC	3.0%	3.9%	4.2%	4.1%	3.3%	3.4%	3.0%	3.1%	3.2%	3.2%
Constrained UCT	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%

8 INDUSTRIAL SECTOR ELECTRIC AND NATURAL GAS ENERGY EFFICIENCY POTENTIAL ESTIMATES

This section provides electric and natural gas energy efficiency potential estimates for the industrial sector in Michigan. Estimates of technical, economic and achievable potential are provided in separate sections for electric and natural gas.

8.1 INDUSTRIAL ELECTRIC ENERGY EFFICIENCY POTENTIAL

According to 2012 historical sales data[44], the industrial sector accounts for approximately 30% of retail electric sales in Michigan. This sector is dominated by the transportation equipment industry which represents almost 25% of industrial electric retail sales. Other key industrial sectors are primary metals and chemicals. Industrial kWh sales over the period 2002 to 2012 reached their highest level in 2003 of almost 40,000 GWh and their lowest level in 2009 of about 27,000 GWh. Since 2009 Industrial sales have rebounded, increasing by 14% to 31,306 GWh in 2012. For this study, industrial electric sales are forecast to continue to increase reaching a level of almost 35,000 GWh in 2023, which represents a compound annual growth rate of slightly less than 1%.[45]

8.1.1 Electric Energy Efficiency Measures Examined

For the industrial sector, there were 116 unique energy efficiency measures included in the energy savings potential analysis. Table 8-1 provides a brief description of the types of measures included for each end use in the industrial sector. The list of measures was developed based on a review of the Michigan Energy Measures Database (MEMD), and measures found in other Technical Reference Manuals (TRMs) and industrial potential studies. For each measure, the analysis considered incremental costs, energy and demand savings, and measure useful measure lives.

Table 8-1: Types of Electric Measures Included in the Industrial Sector Analysis

END USE TYPE	END USE DESCRIPTION	MEASURES INCLUDED
Building Envelope	Building Envelope Improvements	• Wall Insulation R-7.5 to R13 • Below Grade Insulation • Ceiling Insulation R-11 to R-42 • Roof Insulation R-11 to R-24 • Cool Roofing • Energy Efficient Windows
Computers & Office Equipment	Equipment Improvements	• Energy Star Office equipment including computers, monitors, copiers, multi-function machines • PC Network Energy Management Controls replacing no central control • Energy Star Compliant Single Door Refrigerator • Energy Efficient "Smart" Power Strip for PC/Monitor/Printer • EZ Save Monitor Power Management System • Energy Star UPS
Lighting	Lighting Improvements	• CFL Screw in Specialty (& Standard) • CFL Screw-in, Fixtures, and Floods • LED Exit Sign • LED Pin Based Lamp & LED Screw-Ins • Daylight Dimming

[44] U.S. Energy Information Administration
[45] GDS forecast based on sales forecasts provided by DTE and CE and historical industrial sales trends for the state as a whole.

END USE TYPE	END USE DESCRIPTION	MEASURES INCLUDED
		• HID Fixture Upgrade - Pulse Start Metal Halide • Central Lighting Control • High Intensity Fluorescent Fixture (replacing HID) • Stairwell Bi-Level Control • LED Wallpacks • LED Downlights • Remote Mounted Occupancy Sensor • Switching Controls for Multilevel Lighting (Non-HID) • LED Replacing Halogen Incandescent • Controls for H.I.F. • Controls for HID (Hi/Lo) • New Fluorescent Fixtures T5/HP T8 reduced wattage (replacing T12) • Induction Fluorescent • Fluorescent Fixture with Reflectors • Lamp & Ballast Retrofit (HPT8 Replacing T12) • Lamp & Ballast Retrofit (Low Wattage HPT8 Replacing Standard T8) • CFL Exterior Lighting • LED Outdoor Area Fixture (Parking Light or Street Light) • LED Specialty • LED Screw-in • T5 HP replacing T12 • Switch Mounted Occupancy Sensor • Illuminated Signs to LED • CFL Fixture • CFL Flood • 42W 8 lamp Hi Bay CFL • Light Tube • LED Exterior Flood and Spotlight • Fluorescent Fixture with Reflectors • Lamp & Ballast Retrofit (HPT8 Replacing Standard T8) • Lamp & Ballast Retrofit (HPT8 Replacing Standard 12) • New Fluorescent Fixtures T5/HP T8 (replacing T8)
Machine Drive	Machine Drive Improvements	• Compressed Air - Advanced Compressor Controls • Advanced Lubricants • Compressed Air System Management • Pump System Efficiency Improvements • Motor System Optimization (Including ASD) • Electric Supply System Improvements • Sensors & Controls • Fan System Improvements • Advanced Efficient Motors • Industrial Motor Management • Energy Information System
Other		• NEMA Premium Transformer, three-phase • NEMA Premium Transformer, single-phase • Optimized Snow and Ice Melt Controls • Engine Block Heat Timer

END USE TYPE	END USE DESCRIPTION	MEASURES INCLUDED
		• Electrically Commutated Plug Fans in Data Centers • Vendor Miser for Non-Refrigerated Equipment
Process Cooling and Refrigeration	Process Cooling and Refrigeration Improvements	• Improved Refrigeration • Electric Supply System Improvements • Sensors & Controls • Energy Information System
Process Heating	Heating Improvements	• Electric Supply System Improvements • Sensors & Controls • Energy Information System
HVAC Controls	HVAC Control Improvements	• EMS Optimization • EMS install • Programmable Thermostats
Space Cooling - Chillers	Cooling System Upgrades	• Efficient Chilled water Pump • Chilled Hot Water Reset • Water-Cooled Screw Chiller > 300 ton • Air-Cooled Recip Chiller • Water-Cooled Centrifugal Chiller > 300 ton • Air-Cooled Screw Chiller • Water-Cooled Screw Chiller 150 – 300 ton • Water-Cooled Centrifugal Chiller 150 – 300 ton • Water-Cooled Screw Chiller < 150 ton • Water-Cooled Centrifugal Chiller < 150 ton • High Efficiency Pumps
Space Cooling – Unitary and Split AC	Cooling System Upgrades	• Water Loop Heat Pump (WLHP) – Cooling • High Efficiency AC – Unitary & Split Systems • Ductless (mini split) – Cooling • Ground Source Heat Pump - Cooling
Space Heating	Heating System Improvements	• VFD Pump • High Efficiency Pumps • ECM Motors on Furnaces • Water Loop Heat Pump (WLHP) - Heating • Ground Source Heat Pump – Heating • High Efficiency Heat Pump • Ductless (mini split) – Heating
Ventilation	Ventilation Equipment	• Electronically-Commutated Permanent Magnet Motors (ECPMs) • Demand-Controlled Ventilation • High Performance Air Filters • Variable Speed Drive Control, 15 HP • Variable Speed Drive Control, 5 HP • Variable Speed Drive Control, 40 HP • Controlled Ventilation Optimization • Improved Duct Sealing • Enthalpy Economizer • Destratification Fan
Water Heating	Water Heating Improvements	• Low Flow Faucet Aerator • Tank Insulation (electric) • Heat Pump Water Heater • Efficient Hot Water Pump • Hot Water Circulation Pump Time-Clock • Hot Water (DHW) Pipe Insulation • High Efficiency Electric Water Heater • Solar Water Heating System

END USE TYPE	END USE DESCRIPTION	MEASURES INCLUDED
		• Drain Water Heat Recovery Water Heater • Point of Use Water Heating

8.1.2 Technical and Economic Potential Electric Savings

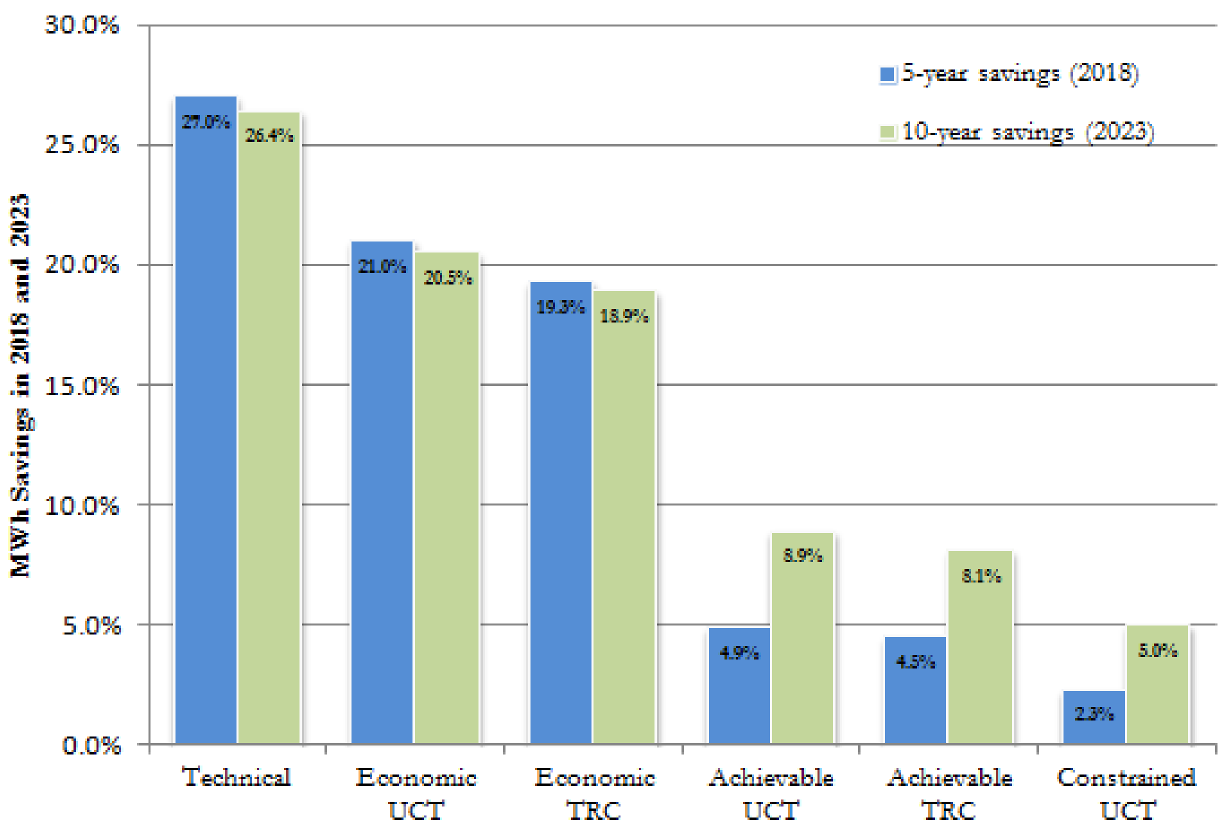
This section presents estimates for electric technical, economic, and achievable savings potential for the industrial sector. Each of the tables in the technical, economic and achievable sections present the respective potential for energy efficiency savings expressed as cumulative annual savings (MWh) and percentage of annual kWh sales. Data is provided for a 5 and 10-year horizon for Michigan

This energy efficiency potential study considers the impacts of the December 2007 Energy and Independence and Security Act (EISA) as an improving code standard for the industrial sector. EISA improves the baseline efficiency of compact fluorescent lamps (CFL), general service fluorescent lamps (GSFL), high intensity discharge (HID) lamps and ballasts and motors, all applicable in the industrial sector.

SUMMARY OF FINDINGS

Figure 8-1 illustrates the estimated savings potential in Michigan for each of the scenarios included in this study.

Figure 8-1: Summary of Industrial Electric Energy Efficiency Potential as a % of Sales Forecasts



The potential estimates are expressed as cumulative annual 5-year and 10-year savings, as percentages of the respective 2018 and 2023 forecasts for industrial sector sales. The technical potential is 27.0% in 2018 and 26.4% in 2023. The 5-year and 10-year economic potential is: 21% and 20.5% based on the Utility Cost Test (UCT) screen, assuming an incentive level equal to 50% of the measure cost. Based on a measure-level screen using the TRC Test, the economic potential is 19.3% in 2018 and 18.9% in 2023. The slight drop from technical potential to economic potential indicates that most measures are cost-effective.

The 5-year and 10-year achievable potential savings are: 4.9% and 8.9% for the Achievable UCT scenario; 4.5% and 8.1% for the Achievable TRC scenario; and 2.3% and 5.0% for the Constrained Achievable scenario. The Achievable UCT scenario assumes 50% incentives and includes measures that passed the UCT Test. The Achievable TRC scenario also assumes 50% incentives but includes only measures that passed the cost-effectiveness screen based on the TRC Test. Last, the Constrained Achievable scenario is a subset of Achievable UCT scenario, assuming a spending cap on non-residential DSM approximately equal to 2% of future annual industrial revenue. The percent of the non-residential spending cap allocated to the industrial sector is based on the percentage of total non-residential UCT savings that the industrial sector represents. This presumes that the total non-residential spending cap will allocated at the sector level based on where the savings opportunities are found.

TECHNICAL POTENTIAL

Technical potential represents the quantification of savings that can be realized if energy-efficiency measures passing the qualitative screening are applied in all feasible instances, regardless of cost. Table 8-2 shows that the technical potential is more than 9.1 million MWh annually in the industrial sector during the 10 year period from 2014 to 2023 across Michigan, representing 27.0% of 2018 forecast industrial sales and 26.4% of 2023 industrial sales. Machine Drive represents the majority of the potential at 36% of 10-yr savings, while water heating, space heating and office equipment represent the smallest shares, each with less than 2 percent of 10-yr savings. Table 8-3 shows the annual (summer) peak demand savings potential in 2018 and 2023. The ten year summer peak demand savings potential is 1,790 MW, which is 40.6% of the 5-year peak forecast and 39.7% of the 10-year peak forecast.

Table 8-2: Industrial Sector Technical Potential Savings By End Use

END USE	2018 ENERGY SAVINGS (MWH)	% OF 2018 TOTAL	2023 ENERGY SAVINGS (MWH)	% OF 2023 TOTAL
Machine Drive	3,344,311	36%	3,344,311	36%
Ventilation	1,720,439	19%	1,720,439	19%
Lighting	1,663,985	18%	1,663,985	18%
HVAC Controls	364,007	4%	364,007	4%
Process	571,628	6%	571,628	6%
Space Cooling - Chillers	540,901	6%	540,901	6%
Appliances, Computers, Office Equipment	79,561	1%	79,561	1%
Envelope	527,313	6%	527,313	6%
Water Heating	64,490	1%	64,490	1%
Other	108,263	1%	108,263	1%
Space Heating	195,819	2%	195,819	2%
Total	**9,180,717**	**100%**	**9,180,717**	**100%**
% of Annual Sales Forecast	*27.0%*		*26.4%*	

Table 8-3: Industrial Sector Technical Potential Demand Savings

	Summer Peak Demand	
	2018	**2023**
Summary	**MW**	**MW**
Total	**1,790**	**1,790**
% of Peak	*40.6%*	*39.7%*

ECONOMIC POTENTIAL

Economic potential is a subset of technical potential, which only accounts for measures that are cost-effective. This analysis includes two estimates of economic potential. One cost-effectiveness screen is based on the UCT and a second economic potential scenario was screened using the TRC Test. In both scenarios, the utility incentive was assumed to be equal to 50% of the measure incremental cost. The UCT was used for this study because it is mandated in Michigan to be the primary cost-effectiveness test used when considering energy efficiency programs. The TRC Test was also included because it also considers the cost assumed by the participant. 86% of all measures that were included in the electric potential analysis passed the UCT and 73% of all measures passed the TRC Test.

Table 8-4 indicates that the economic potential based on the UCT screen is slightly more than 7.1 million MWh during the 10 year period from 2014 to 2023. This represents 21.0% and 20.5% of industrial sales across the respective 5-year and 10-year timeframes. Machine drive, lighting and process end uses make up a majority of the savings. Table 8-5 shows the economic demand savings potential in 2018 and 2023. The five and ten year summer peak demand savings potential is 1,360 MW, respectively, which is 30.8% and 30.2% of the 5-year and 10-year peak forecasts.

Table 8-4: Industrial Sector Economic Potential (UCT) Savings By End Use

End Use	2018 Energy Savings (MWh)	% of 2018 Total	2023 Energy Savings (MWh)	% of 2023 Total
Machine Drive	3,344,311	47%	3,344,311	47%
Lighting	1,585,959	22%	1,585,959	22%
Ventilation	801,060	11%	801,060	11%
Process	571,628	8%	571,628	8%
HVAC Controls	364,007	5%	364,007	5%
Space Cooling	227,400	2%	227,400	2%
Space Heating	108,263	1%	108,263	1%
Other	162,932	1%	162,932	1%
Appliances, Computers, Office Equipment	70,706	1%	70,706	1%
Water Heating	64,468	1%	64,468	1%
Envelope	32,801	1%	32,801	1%
Total	**7,133,458**	**100%**	**7,133,458**	**100%**

END USE	2018 ENERGY SAVINGS (MWH)	% OF 2018 TOTAL	2023 ENERGY SAVINGS (MWH)	% OF 2023 TOTAL
% of Annual Sales Forecast	*21.0%*		*20.5%*	

Table 8-5: Industrial Sector Economic Potential (UCT) Demand Savings

	SUMMER PEAK DEMAND	
	2018	**2023**
Summary	**MW**	**MW**
Total	**1,360**	**1,360**
% of Peak	*30.8%*	*30.2%*

Table 8-6 shows that the economic potential based on the TRC screen is over 6.5 million MWh during the 10 year period from 2014 to 2023. This represents 19.3% and 18.9% of industrial sales in 2018 and 2023 respectively. As with UCT machine drive, lighting and process again make up a majority of the economic TRC savings potential. Table 8-7 shows the demand savings potential in 2018 and 2023. The five and ten year summer peak demand savings potential is 1,210 MW, which is 27.5% and 26.9% of the 5-year and 10-year peak forecasts.

Table 8-6: Industrial Sector Economic Potential (TRC) Savings By End Use

END USE	2018 ENERGY SAVINGS (MWH)	% OF 2018 TOTAL	2023 ENERGY SAVINGS (MWH)	% OF 2023 TOTAL
Machine Drive	3,344,311	51%	3,344,311	51%
Lighting	1,164,015	18%	1,164,015	18%
Ventilation	672,929	10%	672,929	10%
Process	571,628	9%	571,628	9%
HVAC Controls	364,007	6%	364,007	6%
Space Cooling	165,956	2%	165,956	2%
Envelope	32,838	0%	32,838	0%
Other	107,408	2%	107,408	2%
Appliances, Computers, Office Equipment	68,628	1%	68,628	1%
Water Heating	53,484	1%	53,484	1%
Space Heating	22,812	0%	22,812	0%
Total	**6,568,017**	**100%**	**6,568,017**	**100%**
% of Annual Sales Forecast	*19.3%*		*18.9%*	

Table 8-7: Industrial Sector Economic Potential Demand Savings

	SUMMER PEAK DEMAND	
	2018	**2023**
Summary	**MW**	**MW**

Total	**1,210**	**1,210**
% of Peak	*27.5%*	*26.9%*

8.1.3 Achievable Potential Savings in the Industrial Sector

Achievable potential is an estimate of energy savings that can feasibly be achieved given market barriers and equipment replacement cycles. This study estimated achievable potential for three scenarios. The Achievable UCT Scenario determines the achievable potential of all measures that passed the UCT economic screening assuming incentives equal to 50% of the measure cost. Unlike the economic potential, the industrial achievable potential takes into account the estimated market adoption of energy efficiency measures based on the incentive level and the natural replacement cycle of equipment. The second scenario, Achievable TRC, also assumes incentives set at 50% of the measure incremental cost, but only includes measures that passed the TRC Test economic screening. The third scenario, Constrained UCT, assumes a spending cap equal to 2% of utility revenues, thereby limiting utilities from reaching the ultimate potential estimated in the Achievable UCT scenario.

8.1.3.1 UCT vs. TRC

Tables 8-8 through 8-11 show the estimated savings for the Achievable UCT and Achievable TRC scenarios over 5 and 10 year time horizons. As noted above, both scenarios assume an incentive level approximately equal to 50% of the incremental measure cost and include an estimate 10-year market adoption rates based on incentive levels and equipment replacement cycles. However, because more measures pass the UCT relative to the TRC Test, the Achievable UCT scenario is able to include additional measures that would result in greater savings potential over the next five and ten years. Overall the Achievable UCT scenario results in an achievable potential that is 0.27 million MWh greater, over the next decade, than the achievable TRC scenario.

Table 8-8: Industrial Achievable UCT Potential Electric Energy Savings by End Use

	2018	% OF 2018	2023	% OF 2023
Machine Drive	672,522	40%	1,345,044	44%
Lighting	433,232	26%	798,405	26%
Ventilation	212,221	13%	354,445	11%
HVAC Controls	151,334	9%	216,191	7%
Process	101,464	6%	202,927	4%
Space Cooling	43,943	3%	66,723	2%
Space Heating	7,166	1%	10,789	0%
Other	14,279	1%	27,129	1%
Appliances, Computers, Office Equipment	18,255	0%	35,045	1%
Water Heating	18,555	1%	28,881	1%
Envelope	1,520	0%	2,172	0%
Total	1,674,490	100%	3,087,742	100%
% of Annual Sales Forecast	*4.9%*		*8.9%*	

Table 8-9: Industrial Achievable UCT Potential Demand Savings

	SUMMER PEAK DEMAND	
	2018	**2023**

	SUMMER PEAK DEMAND	
Summary	**MW**	**MW**
Total	**295.8**	**571.1**
% of Peak	*6.7%*	*12.7%*

Table 8-10: Industrial Achievable TRC Potential Electric Energy Savings by End Use

	2018	% OF 2018	2023	% OF 2023
Machine Drive	672,522	44%	1,345,044	48%
Lighting	332,748	22%	597,430	21%
Ventilation	183,798	12%	296,042	11%
HVAC Controls	148,907	10%	212,894	8%
Process	101,464	7%	202,927	7%
Space Cooling	42,949	3%	65,132	2%
Office Equip	18,103	1%	34,741	1%
Space Heat	6,352	0%	9,161	0%
Other	13,893	1%	26,576	1%
Water Heating	14,277	1%	22,728	1%
Envelope	2,628	0%	3,754	0%
Total	1,537,639	100%	2,816,429	100%
% of Annual Sales Forecast	*4.5%*		*8.1%*	

Table 8-11: Industrial Achievable TRC Potential Demand Savings

	SUMMER PEAK DEMAND	
	2018	**2023**
Summary	**MW**	**MW**
Total	**278.5**	**539.2**
% of Peak	*6.3%*	*12.0%*

8.1.3.2 Achievable UCT vs. Constrained UCT

Although the Achievable UCT assumes incentives are set and capped at 50% of the incremental measure cost, and that measures are typically replaced at the end of their useful life, the Achievable UCT scenario also assumes no DSM spending cap to reach all potential participants. In the Constrained UCT scenario, the analysis assumes a spending cap roughly equal to 2% of Michigan annual utility revenues. The percent of the non-residential spending cap allocated to the industrial sector is based on the percentage of total non-residential UCT savings that the industrial sector represents. This presumes that the total non-residential spending cap will be allocated at the sector level based on where the savings opportunities are found. To model the impact of a spending cap the market penetration of all cost effective measures was reduced by the ratio of capped spending to uncapped spending that would be required to achieve the Achievable UCT scenario savings potential.

Tables 8-12 and 8-13 show the estimated savings for the Constrained UCT scenario over 5 and 10 year time horizons. The 5-year and 10-year Constrained UCT potential savings estimates are approximately 786 thousand MWh and 1.7 million MWh. This equates to 2.3% and 5.0% of sector sales in 2018 and 2023. The five and ten year summer demand savings estimates in the Constrained UCT scenario are 138.1 MW and 334.9 MW, respectively, which is 3.1% and 7.4% of the peak forecast in 2018 and 2023.

Table 8-12: Industrial Constrained Achievable Energy Savings by End Use

	2018	% of 2018	2023	% of 2023
End Use	**Energy (MWh)**	**Savings**	**Energy (MWh)**	**Savings**
Machine Drive	326,294	41%	785,827	45%
Lighting	204,780	26%	450,985	26%
Ventilation	95,201	12%	187,716	11%
HVAC Controls	65,900	8%	107,366	6%
Process	47,335	6%	113,998	7%
Space Cooling	19,350	2%	34,036	2%
Computers & Office Equipment	8,437	1%	19,449	1%
Building Envelope	662	0%	1,097	0%
Water Heating	8,209	1%	14,884	1%
Other	2,474	1%	15,007	1%
Space Heating	3,151	0%	5,484	0%
Total	**785,903**	**100%**	**1,735,830**	**100%**
% of Annual Sales Forecast	*2.3%*		*5.0%*	

Table 8-13: Industrial Constrained Achievable Demand Savings

	Summer Peak Demand	
	2018	**2023**
Summary	**MW**	**MW**
Total	**138.1**	**334.9**
% of Peak	*3.1%*	*7.4%*

Figure 8-2 shows the estimated 10-year cumulative annual efficiency savings potential broken out by end use across the entire industrial sector for the Constrained UCT scenario. The Machine Drive end use shows the largest potential for savings at just over 0.78 million MWh, or 45% of total savings, in the Constrained UCT scenario. Lighting is second at just over 0.45 million MWh, or 26% of total savings.

Figure 8-2: Industrial Sector 2023 Constrained UCT Potential Savings by End Use

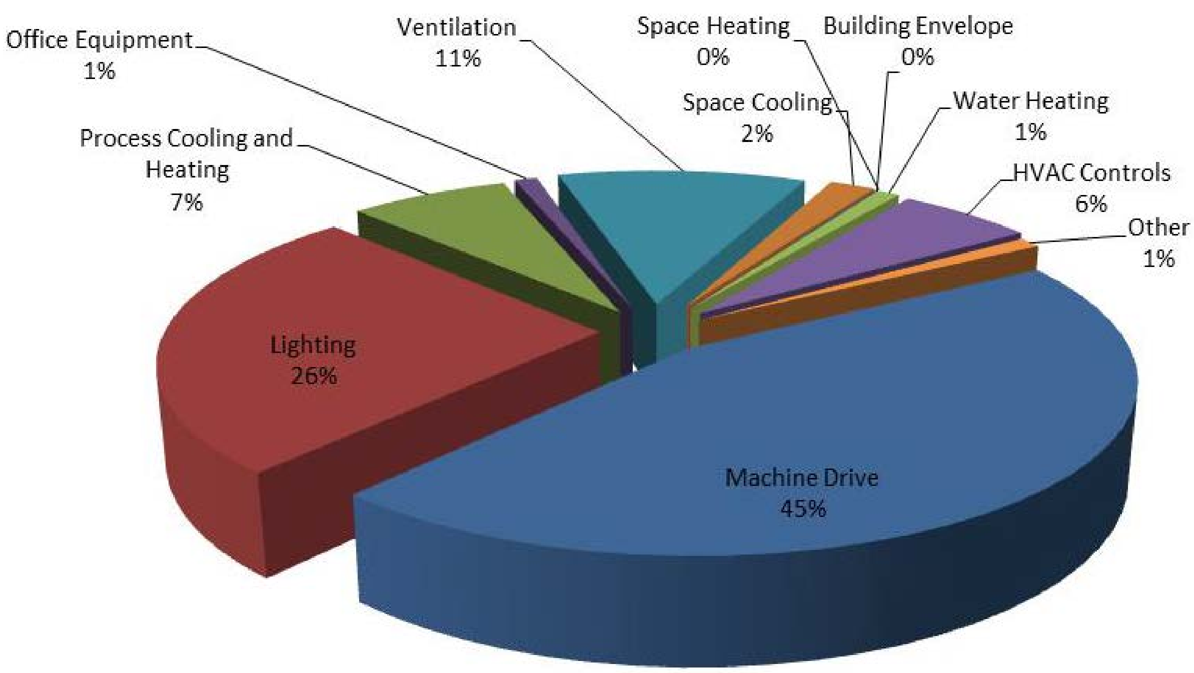
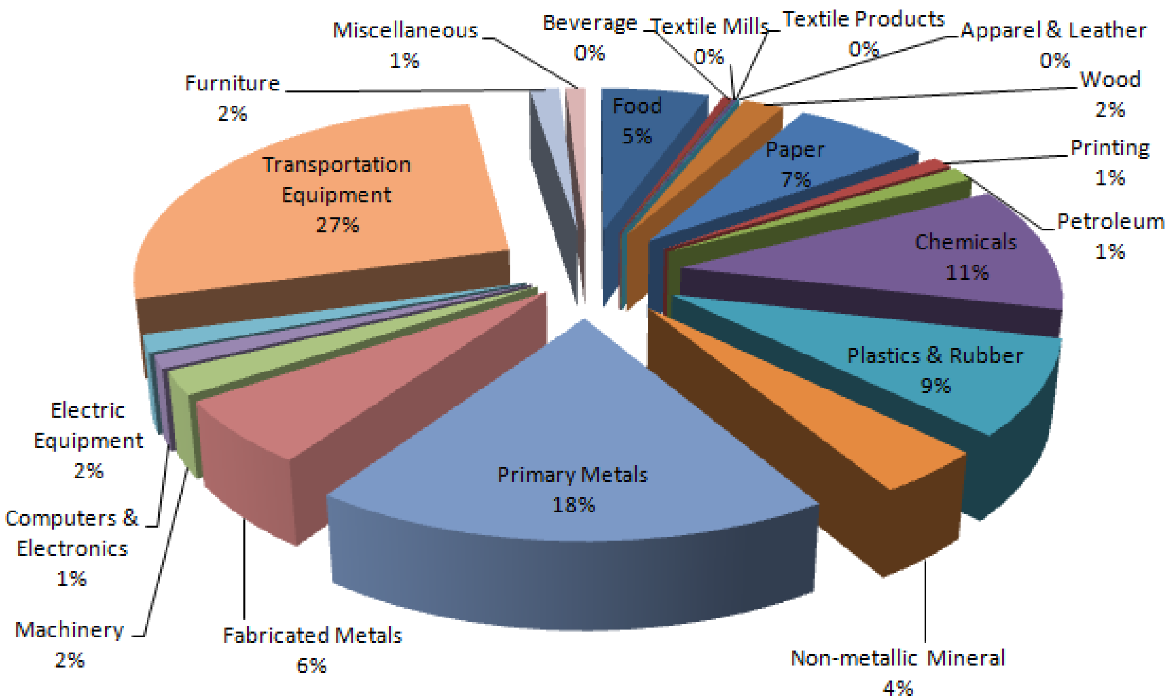


Figure 8-3 shows the breakdown of estimated savings in 2023 by building type for the Constrained UCT scenario. The vast majority of savings come from the transportation equipment, primary metals, chemicals, plastics and rubber, fabricated metals, paper, and food industries; with the other SIC codes accounting for less than 20% of total savings.

Figure 8-3: Industrial Constrained UCT Savings in 2023 by Industry



8.1.4 Annual Achievable Electric Savings Potential

Tables 8-14, Table 8-15 and Table 8-16 show cumulative energy savings for all achievable scenarios for each year across the 10-year horizon for the study, broken out by end use.

Table 8-14: Cumulative Annual Industrial Energy Savings in the Achievable UCT Potential Scenario by End Use

END USE	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Machine Drive	134,504	269,009	403,513	538,017	672,522	807,026	941,530	1,076,035	1,210,539	1,345,044
Lighting	73,540	162,764	258,175	353,546	433,232	512,918	584,761	655,973	727,185	798,405
Ventilation	26,695	70,889	123,833	176,776	212,221	247,665	274,360	301,055	327,750	354,445
HVAC Controls	10,810	43,238	86,476	129,714	151,334	172,953	183,762	194,572	205,381	216,191
Process	20,293	40,585	60,878	81,171	101,464	121,756	1420,49	162,342	182,635	202,927
Space Cooling	4,027	13,345	25,308	37,271	43,943	50,616	54,643	58,669	62,696	66,723
Office Equip	3321	7009	10,880	14,750	18,255	21,759	25,081	28,402	31,724	35,045
Space Heat	636	2,158	4,123	6,087	7,166	8,245	8,881	9,517	10,153	10,789
Other	2534	5426	8496	11566	14279	16992	19526	22060	24594	27129
Water Heat	1,860	5,776	10,721	15,666	18,555	21,443	23,302	25,162	27,021	28,881
Envelope	109	434	869	1,303	1,520	1,738	1,846	1,955	2,064	2,172
Total	**278,327**	**620,633**	**993,271**	**1,365,870**	**1,674,490**	**1,983,110**	**2,259,741**	**2,535,741**	**2,811,742**	**3,087,742**
% of Annual Sales Forecast	*0.9%*	*1.9%*	*3.0%*	*4.1%*	*4.9%*	*5.8%*	*6.6%*	*7.3%*	*8.1%*	*8.9%*

Table 8-15: Cumulative Annual Industrial Energy Savings in the Achievable TRC Potential Scenario by End Use

END USE	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Machine Drive	134,504	269,009	403,513	538,017	672,522	807,026	941,530	1,076,035	1,210,539	1,345,044
Lighting	53,443	122,571	197,885	273,159	332,748	392,337	444,084	495,199	546,315	597,430
Ventilation	20,660	59,208	106,701	154,194	183,798	213,402	234,062	254,722	275,382	296,042
HVAC Controls	10,674	42,579	85,098	127,617	148,907	170,196	180,870	191,545	202,219	212,894
Process	20,293	40,585	60,878	81,171	101,464	121,756	142,049	162,342	182,635	202,927
Space Cooling	3,917	13,026	24,731	36,436	42,949	49,462	53,380	57,297	61,215	65,132
Office Equip	3,291	6,948	10,788	14,629	18,103	21,577	24,868	28,159	31,450	34,741
Space Heat	473	1,832	3,634	5,436	6,352	7,268	7,741	8,214	8,688	9,161
Other	2,507	5,315	8,275	11,235	13,893	16,550	19,057	21,563	24,070	26,576
Water Heat	1,545	4,546	8,275	12,004	14,277	16,549	18,094	19,639	21,183	22,728

END USE	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Envelope	188	751	1,502	2,253	2,628	3,003	3,191	3,379	3,567	3,754
Total	**251,495**	**566,371**	**911,280**	**1,256,150**	**1,537,639**	**1,819,128**	**2,068,926**	**2,318,094**	**2,567,261**	**2,816,429**
% of Annual Sales Forecast	*0.8%*	*1.7%*	*2.8%*	*3.8%*	*4.5%*	*5.3%*	*6.0%*	*6.7%*	*7.4%*	*8.1%*

Table 8-16: Cumulative Annual Industrial Energy Savings in Constrained UCT Potential Scenario by End Use

END USE	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Machine Drive	80,205	140,224	194,641	250,427	326,294	403,355	498,013	594,477	691,256	785,827
Ventilation	43,430	82,862	121,091	160,266	204,780	249,995	300,069	350,650	401,396	450,985
Lighting	15,306	34,268	54,864	75,978	95,201	114,727	132,791	151,200	169,669	187,716
HVAC Controls	6,198	20,112	36,932	54,175	65,900	77,810	85,125	92,579	100,058	107,366
Process	11,635	20,342	28,236	36,329	47,335	58,514	72,246	86,239	100,279	113,998
Space Cooling	2,309	6,307	10,961	15,732	19,350	23,026	25,751	28,528	31,314	34,036
Computers & Office Equipment	1,904	3,487	4,992	6,536	8,437	10,367	12,615	14,905	17,203	19,449
Other	1,453	2,694	3,888	5,112	6,584	8,078	9,793	11,541	13,294	15,007
Water Heating	1,066	2,747	4,670	6,643	8,209	9,800	11,058	12,341	13,627	14,884
Space Heat	365	1,018	1,782	2,565	3,151	3,745	4,175	4,614	5,054	5,484
Building Envelope	62	202	371	544	662	782	855	930	1,005	1,079
Total	163,933	314,261	462,429	614,306	785,903	960,200	1,152,491	1,348,004	1,544,154	1,735,830
% of Annual Sales Forecast	0.5%	1.0%	1.4%	1.8%	2.3%	2.8%	3.4%	3.9%	4.5%	5.0%

Table 8-17: Cumulative Annual Industrial Demand Savings in the Achievable UCT Potential Scenario by End Use

END USE	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Machine Drive	23.2	46.5	69.7	92.9	116.2	139.4	162.6	185.8	209.1	232.3
Lighting	14.6	33.2	53.4	73.5	89.6	105.7	119.8	133.7	147.7	161.8
Process	3.5	7.0	10.5	14.0	17.5	21.0	24.5	28.0	31.5	35.0
Ventilation	2.4	4.9	7.3	9.8	12.2	14.7	17.2	19.6	22.0	24.5
Space Cooling	1.2	2.7	4.4	6.1	7.4	8.8	10.0	11.1	12.3	13.5
HVAC Controls	0.1	0.4	0.7	1.1	1.2	1.4	1.5	1.6	1.7	1.8
Other	0.8	1.6	2.4	3.2	4.0	4.8	5.6	6.4	7.2	7.9
Office Equipment	9.1	18.3	27.4	36.6	45.7	54.9	64.0	73.2	82.3	91.5
Space Heating	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Water Heating	0.2	0.6	1.0	1.5	1.7	2.0	2.2	2.4	2.6	2.8
Building Envelope	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2
Total	**55.2**	**115.1**	**176.9**	**238.7**	**295.8**	**352.8**	**407.5**	**462.0**	**516.5**	**571.1**
% of Annual Sales Forecast	1.3%	2.7%	4.1%	5.4%	6.7%	7.9%	9.2%	10.3%	11.5%	12.7%

Table 8-18: Cumulative Annual Industrial Demand Savings in the Achievable TRC Potential Scenario by End Use

END USE	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Machine Drive	23.2	46.5	69.7	92.9	116.2	139.4	162.6	185.8	209.1	232.3
Lighting	10.5	25.0	41.5	58.1	70.6	83.1	93.6	104.0	114.5	125.0
Process	3.5	7.0	10.5	14.0	17.5	21.0	24.5	28.0	31.5	35.0
Ventilation	2.4	4.9	7.3	9.8	12.2	14.7	17.2	19.6	22.0	24.5
Space Cooling	0.2	0.3	0.5	0.7	0.9	1.1	1.2	1.4	1.5	1.7
HVAC Controls	0.1	0.4	0.7	1.1	1.2	1.4	1.5	1.6	1.7	1.8
Other	1.2	2.5	3.7	4.9	6.2	7.4	8.6	9.9	11.1	12.3
Office Equipment	9.7	19.4	29.2	38.9	48.6	58.3	68.1	77.8	87.5	97.2
Space Heating	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Water Heating	0.2	0.6	1.0	1.5	1.8	2.1	2.3	2.5	2.7	2.9
Building Envelope	0.6	1.3	1.9	2.6	3.2	3.9	4.5	5.2	5.8	6.4
Total	**51.7**	**107.8**	**166.2**	**224.5**	**278.5**	**332.4**	**384.1**	**435.8**	**487.5**	**539.2**
% of Annual Demand Forecast	1.2%	2.5%	3.8%	5.1%	6.3%	7.5%	8.6%	9.7%	10.9%	12.0%

Table 8-19: Cumulative Annual Industrial Demand Savings in Constrained UCT Potential Scenario by End Use

END USE	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Machine Drive	13.3	22.7	31.5	40.9	55.6	68.6	87.3	103.8	120.2	135.5
Lighting	8.4	16.4	24.1	32.1	41.0	50.0	59.7	69.6	79.3	89.0
Process	2.0	3.5	4.9	6.3	8.2	10.1	12.5	14.9	17.3	19.7
Ventilation	1.4	2.4	3.4	4.4	5.7	7.1	8.8	10.5	12.2	13.8
Space Cooling	0.7	1.3	2.0	2.7	3.4	4.1	4.9	5.8	6.6	7.4
HVAC Controls	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.8	0.9
Other	0.5	0.8	1.1	1.4	1.9	2.3	2.9	3.5	4.2	4.7
Office Equipment	5.2	9.2	12.7	16.4	21.1	27.2	36.0	45.0	54.1	62.5
Space Heating	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Water Heating	0.1	0.3	0.4	0.6	0.8	0.9	1.1	1.2	1.3	1.4
Building Envelope	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1
Total	**31.6**	**56.8**	**80.4**	**105.2**	**138.1**	**171.0**	**214.0**	**255.1**	**296.0**	**334.9**
% of Annual Demand Forecast	0.8%	1.3%	1.9%	2.4%	3.1%	3.8%	4.8%	5.7%	6.6%	7.4%

8.1.5 Industrial Electric Savings Summary by Measure Group

Table 8-20 below provides an end-use breakdown of the industrial electric savings potential estimates for technical and economic potential, and each of the three achievable potential scenarios. The table indicates how the savings potential decreases systematically from the technical potential scenario to the Constrained UCT potential scenario as additional limiting factors such as cost-effectiveness requirements and anticipated market adoption at given funding levels are introduced.

Table 8-20 Electric Potential by End-Use and Measure

END USE	TECHNICAL POTENTIAL (MWH)	ECONOMIC POTENTIAL -UCT- (MWH)	ECONOMIC POTENTIAL -TRC- (MWH)	ACHIEVABLE POTENTIAL -UCT- (MWH)	ACHIEVABLE POTENTIAL -TRC- (MWH)	CONSTRAINED ACHIEVABLE -UCT- (MWH)
Water Heating						
Low Flow Faucet Aerator	16,458	16,458	16,458	3,542	3,542	1,759
Heat Pump Water Heater	15,728	15,728	15,728	6,620	6,620	3,719
Tank Insulation (electric)	14,885	14,885	14,885	9,940	9,940	4,937
Solar Water Heating System	10,539	10,539	0	6,007	0	0
High Efficiency Electric Water Heater	3,177	3,177	3,177	1,543	1,543	867
Efficient Hot Water Pump	3,005	3,005	3,005	943	943	468
Drain water Heat Recovery Water Heater	446	446	0	147	0	82
Hot Water (DHW) Pipe Insulation	174	174	174	113	113	56
Hot Water Circulation Pump Time-Clock	56	56	56	26	26	13
Point of Use Water Heating	22	0	0	0	0	0
Ventilation						
Enthalpy Economizer	895,829	0	0	0	0	22,196
Demand-Controlled Ventilation	196,425	196,425	196,425	84,211	84,211	47,307
High Performance Air Filters	145,378	145,378	145,378	16,564	16,564	9,305
Improved Duct Sealing	139,823	0	0	0	0	0
Variable Speed Drive Control, 5 HP	96,838	96,838	96,838	58,331	58,331	28,968
Variable Speed Drive Control, 40 HP	96,838	96,838	96,838	58,331	58,331	28,968
Variable Speed Drive Control, 15 HP	96,838	96,838	96,838	58,331	58,331	28,968
Electronically-Commutated Permanent Magnet Motors (ECPMs)	38,207	38,207	38,207	15,441	15,441	8,674
Destratification Fan	11,858	0	0	0	0	0
Controlled Ventilation Optimization	2,405	2,405	2,405	943	943	530
Space Cooling - Chillers						
Chilled Hot Water Reset	59,940	59,940	104,809	36,899	64,521	23,479
Efficient Chilled Water Pump	18,897	18,897	33,042	3,596	6,289	2,288

END USE	TECHNICAL POTENTIAL (MWH)	ECONOMIC POTENTIAL -UCT- (MWH)	ECONOMIC POTENTIAL -TRC- (MWH)	ACHIEVABLE POTENTIAL -UCT- (MWH)	ACHIEVABLE POTENTIAL -TRC- (MWH)	CONSTRAINED ACHIEVABLE -UCT- (MWH)
Air-Cooled Screw Chiller	14,824	14,824	14,824	3,202	3,202	1,799
Air-Cooled Recip Chiller	14,604	14,604	14,604	3,155	3,155	1,772
High Efficiency Pumps	3,001	3,001	12,378	571	2,356	509
Water-Cooled Centrifugal Chiller < 150 ton	2,932	2,932	2,932	633	633	356
Water-Cooled Centrifugal Chiller > 300 ton	2,929	2,929	2,929	633	633	355
Water-Cooled Centrifugal Chiller 150 - 300 ton	2,908	2,908	2,908	628	628	353
Water-Cooled Screw Chiller > 300 ton	2,755	2,755	2,755	595	595	334
Water-Cooled Screw Chiller 150 - 300 ton	2,527	2,527	2,527	546	546	307
Water-Cooled Screw Chiller < 150 ton	2,019	2,019	2,019	436	436	245
Space Cooling - Unitary and Split AC						
Ground Source Heat Pump - Cooling	170,048	19,588	0	4,972	0	0
Ductless (mini split) - Cooling	169,368	0	0	0	0	0
High Efficiency AC - Unitary & Split Systems	63,112	63,112	0	22,784	0	12,799
Water Loop Heat Pump (WLHP) - Cooling	11,039	11,039	11,039	3,985	3,985	2,239
Lighting						
New Fluorescent Fixtures T5/HP T8 (replacing T12)	128,982	128,982	0	49,603	0	28,701
Induction Fluorescent	104,252	104,252	104,252	53,870	53,870	31,170
High Intensity Fluorescent Fixture (replacing HID)	94,044	94,044	94,044	45,294	45,294	26,208
T5 HP replacing T12	86,105	86,105	0	41,392	0	23,950
LED Exterior Flood and Spotlight	69,735	3,953	0	2,567	0	0
LED Wallpack	66,853	66,853	66,853	28,945	28,945	16,748
42W 8 lamp Hi Bay CFL	63,350	63,350	0	34,099	0	19,730
CFL Exterior Lighting	58,985	58,985	58,985	28,141	28,141	16,283
Light Tube	58,510	58,510	0	26,947	0	15,592
New Fluorescent Fixtures T5/HP T8 reduced wattage (replacing T8)	43,239	43,239	43,239	0	0	0

END USE	TECHNICAL POTENTIAL (MWH)	ECONOMIC POTENTIAL -UCT- (MWH)	ECONOMIC POTENTIAL -TRC- (MWH)	ACHIEVABLE POTENTIAL -UCT- (MWH)	ACHIEVABLE POTENTIAL -TRC- (MWH)	CONSTRAINED ACHIEVABLE -UCT- (MWH)
HID Fixture Upgrade - Pulse Start Metal Halide	41,385	41,385	41,385	9,515	9,515	5,506
Lamp & Ballast Retrofit (HPT8 Replacing T12)	41,380	41,380	41,380	19,892	19,892	11,299
Fluorescent Fixture with Reflectors	12,814	12,814	12,814	0	0	0
Lamp & Ballast Retrofit (Low Wattage HPT8 Replacing Standard T8)	11,223	11,223	11,223	0	0	0
LED Specialty	10,936	10,936	10,936	6,504	6,504	3,763
CFL Screw in Specialty	10,115	10,115	10,115	6,015	6,015	3,480
LED Outdoor Area Fixture (Parking Light or Street Light)	10,028	10,028	10,028	5,010	5,010	2,899
CFL Screw-in	6,576	6,576	6,576	3,911	3,911	2,045
LED Screw In	7,919	7,919	7,919	3,140	3,140	1,817
Lamp & Ballast Retrofit (HPT8 Replacing Standard T8)	7,576	11,223	0	0	0	0
LED Pin Based Lamp	7,299	7,299	7,299	2,894	2,894	1,674
LED Exit Sign	4,231	4,231	4,231	285	285	165
Illuminated Signs to LED	3,953	0	0	0	0	1,486
CFL Fixture	1,259	1,259	1,259	624	624	325
CFL Flood	1,029	1,029	1,029	612	612	354
LED Replacing Halogen Incandescent	954	954	954	567	567	328
LED Downlight	839	839	839	483	483	280
Lighting Controls						
Daylight Dimming	241,517	241,517	241,517	156,853	156,853	80,234
Central Lighting Control	138,674	138,674	138,674	75,052	75,052	43,427
Switching Controls for Multilevel Lighting (Non-HID)	89,312	89,312	89,312	48,073	48,073	27,816
Switch Mounted Occupancy Sensor	73,469	73,469	0	46,359	0	26,824
Remote Mounted Occupancy Sensor	73,469	73,469	73,469	46,359	46,359	26,824
Stairwell Bi-Level Control	68,331	68,331	68,331	44,132	44,132	25,536
Controls for H.I.F.	17,350	17,350	17,350	11,268	11,268	6,520

End Use	Technical Potential (MWh)	Economic Potential -UCT- (MWh)	Economic Potential -TRC- (MWh)	Achievable Potential -UCT- (MWh)	Achievable Potential -TRC- (MWh)	Constrained Achievable -UCT- (MWh)
Controls for HID (Hi/Lo)	8,291	0	0	0	0	0
Appliances, Computers, Office Equipment						
Energy Star office equipment including computers, monitors, copiers, multi-function machines.	61,212	61,212	61,212	31,080	31,080	17,460
Energy Efficient "Smart" Power Strip for PC/Monitor/Printer	7,839	0	0	0	0	0
PC Network Energy Management Controls replacing no central control	7,416	7,416	7,416	3,661	3,661	1,818
Energy Star Compliant Single Door Refrigerator	2,078	2,078	0	304	0	171
EZ Save Monitor Power Management Software	753	0	0	0	0	0
Energy Star UPS	263	0	0	0	0	0
Building Envelope						
Cool Roofing	291,304	0	0	0	0	0
Energy Efficient Windows	97,752	0	0	0	0	0
Ceiling Insulation R-11 to R-42	81,842	0	0	0	0	0
Wall Insulation R-7.5 to R13	29,969	29,969	31,280	1,457	1,521	736
Roof Insulation R-11 to R-24	24,134	0	0	0	0	0
Below Grade Insulation	2,311	2,311	2,423	683	716	343
HVAC Controls						
EMS install	239,198	239,198	239,198	147,252	147,252	73,129
Programmable Thermostats	99,062	99,062	99,062	53,089	53,089	73,129
EMS Optimization	25,747	25,747	25,747	15,850	15,850	7,872
Space Heating						
Ductless (mini split) - Heating	93,982	0	0	0	0	0
Ground Source Heat Pump - Heating	62,548	0	0	0	0	0
VFD Pump	14,151	14,151	14,151	7,663	7,663	3,805
High Efficiency Heat Pump	11,967	28,754	0	0	0	0
ECM motors on furnaces	6,289	6,289	6,289	1,197	1,197	594

END USE	TECHNICAL POTENTIAL (MWH)	ECONOMIC POTENTIAL -UCT- (MWH)	ECONOMIC POTENTIAL -TRC- (MWH)	ACHIEVABLE POTENTIAL -UCT- (MWH)	ACHIEVABLE POTENTIAL -TRC- (MWH)	CONSTRAINED ACHIEVABLE -UCT- (MWH)
Water Loop Heat Pump (WLHP) - Heating	4,510	4,510	0	1,628	0	915
High Efficiency Pumps	2,372	2,372	2,372	301	301	169
Other						
NEMA Premium Transformer, three-phase	59,972	59,972	59,972	12,761	12,761	7,169
NEMA Premium Transformer, single-phase	38,231	38,231	38,231	8,135	8,135	4,570
Optimized Snow and Ice Melt Controls	4,682	4,682	4,682	3,022	3,022	1,501
Engine Block Heater Timer	3,306	3,306	3,306	2,135	2,135	1,199
Electrically Commutated Plug Fans in data centers	1,217	1,217	1,217	524	524	294
Vendor Miser for Non-Refrig Equipment	855	855	0	552	0	274
Process Heating						
Electric Supply System Improvements	115,369	115,369	115,369	39,233	39,233	22,040
Sensors & Controls	112,867	112,867	112,867	38,378	38,378	21,559
Energy Information System	36,807	36,807	36,807	12,514	12,514	7,030
Process Cooling and Refrigeration						
Improved Refrigeration	132,031	132,031	132,031	48,585	48,585	27,294
Electric Supply System Improvements	76,090	76,090	76,090	27,995	27,995	15,727
Sensors & Controls	74,287	74,287	74,287	27,329	27,329	15,353
Energy Information System	24,176	24,176	24,176	8,893	8,893	4,996
Machine Drive						
Motor System Optimization (Including ASD)	1,595,219	1,595,219	1,595,219	612,224	612,224	357,685
Pump System Efficiency Improvements	387,428	387,428	387,428	148,984	148,984	87,042
Compressed Air System Management	324,440	324,440	324,440	187,765	187,765	109,700
Electric Supply System Improvements	278,666	278,666	278,666	106,905	106,905	62,458
Sensors & Controls	272,349	272,349	272,349	104,474	104,474	61,038
Advanced Efficient Motors	162,603	162,603	162,603	37,425	37,425	21,865
Energy Information System	86,616	86,616	86,616	33,224	33,224	19,411

END USE	TECHNICAL POTENTIAL (MWH)	ECONOMIC POTENTIAL -UCT- (MWH)	ECONOMIC POTENTIAL -TRC- (MWH)	ACHIEVABLE POTENTIAL -UCT- (MWH)	ACHIEVABLE POTENTIAL -TRC- (MWH)	CONSTRAINED ACHIEVABLE -UCT- (MWH)
Industrial Motor Management	69,714	69,714	69,714	40,112	40,112	23,435
Compressed Air - Advanced Compressor Controls	67,391	67,391	67,391	26,002	26,002	15,191
Advanced Lubricants	51,830	51,830	51,830	29,847	29,847	17,438
Fan System Improvements	48,056	48,056	48,056	18,082	18,082	10,564
Total	**9,180,717**	**7,133,458**	**6,568,017**	**3,087,742**	**2,816,429**	**1,735,830**
% of Annual Sales Forecast	**26.4%**	**20.5%**	**18.9%**	**8.9%**	**8.1%**	**5.0%**
Note: Measures in the above Table with "0" achievable potential are ones that did not pass the SCT Test.						

Table 8-21 provides a list of the Top 10 industrial electric savings measures for the Achievable UCT scenario. The table provides the measures ranked according to the electric savings potential. The column to the far right shows the results of the measure level cost-effectiveness screening test using the UCT to screen the measures. The table presents an average of the UCT ratios for all measures which are part of the measure categories in the Top 10.

The Top 10 measures combine to yield an estimated 1,682,050 MWh savings. This accounts for 54% of the total industrial electric savings in the Achievable UCT scenario.

Table 8-21: Top 10 Industrial Electric Savings Measures in the Achievable UCT Scenario

MEASURE	2023 ENERGY (MWH)	% OF SECTOR SAVINGS	UCT RATIO
1. Motor System Optimization (Including ASD)	612,224	20%	18.88
2. Compressed Air System Management	187,765	6%	16,869.70
3. Daylight Dimming	156,853	5%	7.57
4. Pump System Efficiency Improvements	148,984	5%	22.06
5. EMS install	147,252	5%	87.52
6. Electric Supply System Improvements (Motors)	106,905	3%	17.61
7. Sensors & Controls (Motors)	104,474	3%	12.63
8. Demand-Controlled Ventilation	84,211	3%	5.00
9. Central Lighting Control	75,052	2%	7.54
10. Variable Speed Drive Control, 40 HP	58,331	2%	2.69
Total	**1,682,050**	**54%**	

8.2 INDUSTRIAL NATURAL GAS POTENTIAL

The GDS Associates natural gas consumption forecasts for the residential, commercial and industrial segments of the Michigan economy indicates that annual natural gas consumption will decrease by about 10% from 656.2 trillion BTU in 2013 to 587.2 trillion BTU in 2023.[46] Over that same period industrial natural gas use is expected to decline by about 4% from 2012 levels.

8.2.1 Natural Gas Energy Efficiency Measures Examined

For the industrial sector, there were 44 unique natural gas energy efficiency measures included in the potential natural gas savings analysis. Table 8-18 provides a brief description of the types of natural gas energy efficiency measures included for each end use in the industrial sector. The list of measures was developed based on a review of the Michigan Energy Measures Database (MEMD), and measures found in other Technical Reference Manuals (TRMs) and industrial potential studies. For each measure, the analysis considered incremental costs, energy savings, and useful measure life.

[46] GDS applied a forecast trends to actual deliveries by customer classes as reported by the U.S. Energy Information Administration (EIA). The annual sales forecast trends are based the EIA's Long term Reference Case forecast of natural gas consumption for the East North Central Region (Illinois, Indiana, Michigan, Ohio, and Wisconsin) as reported in the EIA 2013 Annual Energy Outlook.

Table 8-22: Measures and Programs Included in the Industrial Sector Analysis

END USE TYPE	END USE DESCRIPTION	MEASURES/PROGRAMS INCLUDED
Building Envelope	Building Insulation & Air Sealing	• Wall Insulation R-7.5 to R13 • Below Grade Insulation • Ceiling Insulation R-11 to R-42 • Energy Efficient Windows • Roof Insulation R-11 to R-24
Conventional Boiler Use	Boiler Improvements	• Insulate Steam Lines / Condensate Tank • Repair Malfunctioning Steam Traps • High Efficiency Hot Water Boiler (>300,000 Btu/h) • Condensing Boiler (>300,000 Btu/h) (EF>90%) • Boiler Pipe Insulation • High Efficiency Steam Boiler (>300,000 Btu/h) • Boiler Reset Controls • Boiler Blowdown Heat Exchanger (Steam) • High Efficiency Hot Water Boiler (<=300,000 Btu/h) • Boiler Tune-Up • High Efficiency Steam Boiler (<=300,000 Btu/h) • Condensing Boiler (<=300,000 Btu/h) • Boiler O2 Trim Controls • Electronic Parallel Positioning Controls (linkage less)
Facility HVAC	HVAC improvements	• Stack Heat Exchanger (Condensing Economizer) • Stack Heat Exchanger (Standard Economizer) • High Efficiency Furnace (<=300,000 Btu/h) • Infrared Heater (low intensity - two stage) • Direct Fired Make-up Air System • Gas Unit Heater - Condensing • Heat Recovery: Air to Air • Insulate and Seal Ducts (New Aerosl Duct Sealing)
HVAC Controls	HVAC Controls Improvement	• EMS Optimization • EMS install • Programmable Thermostats
Process Heating	Process Heating Improvements	• Regenerative Thermal Oxidizer vs. STO • Boiler Pipe Insulation • High Efficiency Hot Water Boiler (>300,000 Btu/h)

END USE TYPE	END USE DESCRIPTION	MEASURES/PROGRAMS INCLUDED
		• Condensing Boiler (>300,000 Btu/h) (EF>90%) • High Efficiency Steam Boiler (>300,000 Btu/h) • Boiler Reset Controls • Boiler Tune-Up • Regenerative Thermal Oxidizer vs. CTO • Improved Sensors & Process Controls • Boiler O2 Trim Controls • Electronic Parallel Positioning Controls (linkage less) • Waste-Heat Recovery
Ventilation	Ventilation & Fans	• Demand-Controlled Ventilation • Controlled Ventilation Optimization • Improved Duct Sealing • Destratification Fan

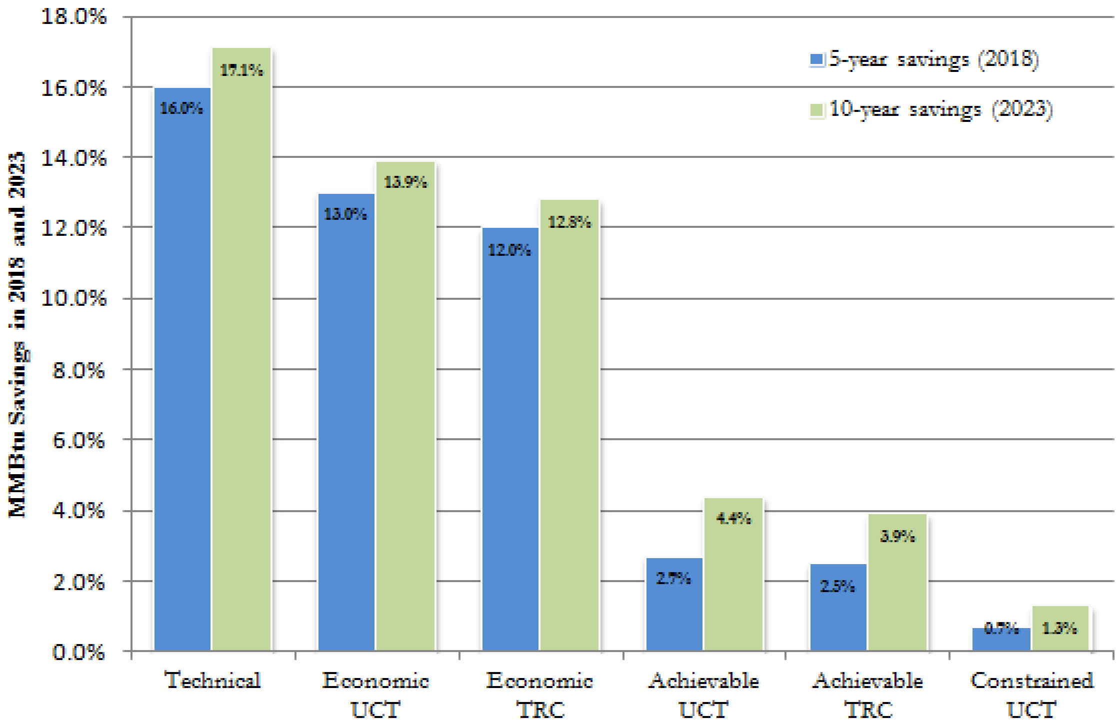
8.2.2 Technical and Economic Potential Natural Gas Savings

This section presents estimates for natural gas technical, economic, and achievable potential for the industrial sector. Each of the tables in the technical, economic and achievable sections present the respective potential for efficiency savings expressed as cumulative savings (MMBtu) and percentage of sales. Data is provided for a 5 and 10-year horizon for Michigan

SUMMARY OF FINDINGS

Figure 8-4 illustrates the estimated savings potential for each of all the scenarios included in this study.

Figure 8-4: Summary of Industrial Natural Gas Energy Efficiency Potential as a % Sales Forecasts



The potential estimates are expressed as cumulative 5-year and 10-year savings, as percentages of the respective 2018 and 2023 industrial sector sales. The technical potential is 16.0% in 2018 and 17.1% in 2023. The 5-year and 10-year economic potential is 13.0% and 13.9% based on the Utility Cost Test (UCT) screen, assuming an incentive level equal to 50% of the measure cost. Based on a measure-level screen using the TRC Test, the economic potential is 12.0% in 2018 and 12.8% in 2023. The slight drop from technical potential to economic potential indicates that most measures are cost-effective.

The 5-year and 10-year achievable potential savings are: 2.7% and 4.4% for the Achievable UCT scenario; 2.5% and 3.9% for the Achievable TRC scenario; and 0.7% and 1.3% for the Constrained Achievable scenario. The Achievable UCT scenario assumes 50% incentives and includes measures that passed the UCT Test. The Achievable TRC scenario also assumes 50% incentives but includes only measures that passed the cost-effectiveness screen based on the TRC Test. Last, the Constrained Achievable scenario is a subset of Achievable UCT scenario, assuming a spending cap on non-residential DSM approximately equal to 2% of future annual industrial and industrial revenue. The percent of the non-residential spending cap allocated to the industrial sector is based on the percentage of total non-residential UCT savings that the industrial sector represents. This presumes that the total non-residential spending cap will allocated at the sector level based on where the savings opportunities are found.

TECHNICAL POTENTIAL

Technical potential represents the quantification of savings that can be realized if energy-efficiency measures passing the qualitative screening are applied in all feasible instances, regardless of cost. Table 8-23 shows that it is technically feasible to save over 26 million MMBtu during the 10 year period from 2013 to 2023 across Michigan, representing just over 16.0% and 17.1% of 2018 and 2023 sector sales, respectively. Process heating represents the majority of the potential at 41% of 10-yr savings, while ventilation and Ventilation represent the smallest share with 3 percent of 10-yr savings.

Table 8-23: Industrial Sector Technical Potential MMBtu Savings By End Use

END USE	2018 ENERGY SAVINGS (MMBTU)	% OF 2018 TOTAL	2023 ENERGY SAVINGS (MMBTU)	% OF 2023 TOTAL
Process Heating	11,449,066	44%	11,449,066	44%
Facility HVAC	7,623,712	29%	7,623,712	29%
Conventional Boiler Use	3,225,394	12%	3,225,394	12%
Envelope	2,728,383	10%	2,728,383	10%
HVAC Controls	1,796,940	7%	1,796,940	7%
Ventilation	893,366	3%	893,366	3%
Lighting	-1,533,839	-6%	-1,533,839	-6%
Total	**26,183,022**	**100%**	**26,183,022**	**100%**
Percent of Annual Sales Forecast	16.0%		17.1%	

ECONOMIC POTENTIAL

Economic potential is a subset of technical potential, which only accounts for measures that are cost-effective. This analysis includes two estimates of economic potential. One cost-effectiveness screen is based on the UCT and a second economic potential scenario was screened using the TRC Test. In both scenarios, the utility incentive was assumed to be equal to 50% of the measure incremental cost. The UCT was used for this study because it is mandated in Michigan to be the primary cost-effectiveness test used when considering energy efficiency programs. Because the TRC includes participant costs, it goes beyond utility resource acquisition and looks at the measure/program from a more broad perspective. 77% of all measures that were included in the electric potential analysis passed the UCT and 75% of all measures passed the TRC Test.

Table 8-24 indicates that the economic potential based on the UCT screen is just over 21 million MMBTu during the 10 year period from 2014 to 2023. This represents 13.0% and 13.9% of industrial sales in 2018 and 2023. Process heating again makes up a majority of the savings.

Table 8-24: Industrial Sector Economic Natural Gas UCT Savings By End Use

END USE	2018 ENERGY SAVINGS (MMBTU)	% OF 2018 TOTAL	2023 ENERGY SAVINGS (MMBTU)	% OF 2023 TOTAL
Process Heating	10,011,269	47%	10,011,269	47%
Facility HVAC	6,362,046	30%	6,362,046	30%
HVAC Controls	3,069,341	14%	3,069,341	14%
Conventional Boiler Use	1,796,940	8%	1,796,940	8%
Ventilation	893,366	4%	893,366	4%
Envelope	574,166	3%	574,166	3%
Lighting	-1,516,602	-7%	-1,516,602	-7%
Total	**21,190,526**	**100%**	**21,190,526**	**100%**
Percent of Annual Sales Forecast	13.0%		13.9%	

Table 8-25 shows that the economic potential based on the TRC screen is over 19 million MMBtu during the 10 year period from 2014 to 2023. This represents 12.0% and 12.8% of industrial sales in

2018 and 2023. As with UCT process heating measures continue to makes up a majority of the savings potential.

Table 8-25: Industrial Sector Economic Natural Gas TRC Savings By End Use

END USE	2018 ENERGY SAVINGS (MMBTU)	% OF 2018 TOTAL	2023 ENERGY SAVINGS (MMBTU)	% OF 2023 TOTAL
Process Heating	8,400,649	43%	8,400,649	43%
Facility HVAC	6,362,046	32%	6,362,046	32%
HVAC Controls	3,071,321	16%	3,071,321	16%
Conventional Boiler Use	1,796,940	9%	1,796,940	9%
Ventilation	893,366	5%	893,366	5%
Envelope	574,166	3%	574,166	3%
Lighting	-1,486,891	-8%	-1,486,891	-8%
Total	**19,611,597**	**100%**	**19,611,597**	**100%**
Percent of Annual Sales Forecast	12.0%		12.8%	

8.2.3 Achievable Potential Savings in the Industrial Sector

Achievable potential is an estimate of energy savings that can feasibly be achieved given market barriers and equipment replacement cycles. This study estimated achievable potential for three scenarios. The Achievable UCT Scenario determines the achievable potential of all measures that passed the UCT economic screening assuming incentives equal to 50% of the measure cost. Unlike the economic potential, the industrial achievable potential takes into account the estimated market adoption of energy efficiency measures based on the incentive level and the natural replacement cycle of equipment. The second scenario, Achievable TRC, also assumes incentives set at 50% of the measure incremental cost, but only includes measures that passed the TRC Test economic screening. The third scenario, Constrained UCT, assumes a spending cap equal to 2% of utility revenues, thereby limiting utilities from reaching the ultimate potential estimated in the Achievable UCT scenario.

8.2.3.1 UCT vs. TRC

Tables 8-26 and 8-27 show the estimated savings for the Achievable UCT and Achievable TRC scenarios over 5 and 10 year time horizons. As noted above, both scenarios assume an incentive level approximately equal to 50% of the incremental measure cost and include an estimate 10-year market adoption rates based on incentive levels and equipment replacement cycles. However, because more measures pass the UCT relative to the TRC Test, the Achievable UCT scenario is able to include additional measures that would result in greater savings potential over the next five and ten years. Overall the Achievable UCT scenario results in an achievable potential that is slightly less than eight million MMBtu greater, over the next decade, than the achievable TRC scenario.

Table 8-26: Industrial Achievable UCT Natural Gas Potential Savings by End Use

END USE	2018 ENERGY SAVINGS (MMBTU)	% OF 2018 TOTAL	2023 ENERGY SAVINGS (MMBTU)	% OF 2023 TOTAL
Process Heating	2,187,112	49%	3,295,968	49%
Facility HVAC	1,004,760	23%	1,664,228	25%
HVAC Controls	747,065	17%	1,067,236	16%
Conventional Boiler Use	603,287	14%	933,864	14%
Ventilation	211,567	5%	366,527	5%

END USE	2018 ENERGY SAVINGS (MMBTU)	% OF 2018 TOTAL	2023 ENERGY SAVINGS (MMBTU)	% OF 2023 TOTAL
Envelope	79,173	2%	113,104	2%
Lighting	-381,744	-9%	-763,489	-11%
Total	4,451,220	**100%**	6,677,438	**100%**
Percent of Annual Sales Forecast	2.7%		4.4%	

Table 8-27 Industrial Achievable TRC Natural Gas Potential Savings by End Use

END USE	2018 ENERGY SAVINGS (MMBTU)	% OF 2018 TOTAL	2023 ENERGY SAVINGS (MMBTU)	% OF 2023 TOTAL
Process Heating	1,721,341	43%	2,630,580	44%
Facility HVAC	1,004,760	25%	1,664,228	28%
Conventional Boiler Use	747,065	19%	1,067,236	18%
Ventilation	603,859	15%	934,681	16%
HVAC Controls	211,567	5%	366,527	6%
Envelope	79,173	2%	113,104	2%
Lighting	-381,573	-10%	-763,146	-13%
Total	**3,986,192**	**100%**	**6,013,211**	**100%**
Percent of Annual Sales Forecast	2.5%		3.9%	

8.2.3.2 Achievable UCT vs. Constrained UCT

Although the Achievable UCT assumes incentives are set and capped at 50% of the incremental measure cost, and that measures are typically replaced at the end of their useful life, the Achievable UCT scenario also assumes no DSM spending cap to reach all potential participants. In the Constrained UCT scenario, the analysis assumes a spending cap roughly equal to 2% of Michigan utility revenue. The percent of the non-residential spending cap allocated to the industrial sector is based on the percentage of total non-residential UCT savings that the industrial sector represents. This presumes that the total non-residential spending cap will be allocated at the sector level based on where the savings opportunities are found. To model the impact of a spending cap the market penetration of all cost effective measures was reduced by the ratio of capped spending to uncapped spending that would be required to achieve the Achievable UCT scenario savings potential.

Table 8-28 shows the estimated savings for the Constrained UCT scenario over 5 and 10 year time horizons. The 5-year and 10-year Constrained UCT potential savings estimates are approximately 1,070 thousand MMBtu and 2,039 thousand MMBtu. This equates to 0.7% and 1.3% of sector sales in 2018 and 2023.

Table 8-28: Industrial Constrained UCT Natural Gas Achievable Energy Savings by End Use

END USE	2018 ENERGY SAVINGS (MMBTU)	% OF 2018 TOTAL	2023 ENERGY SAVINGS (MMBTU)	% OF 2023 TOTAL
Process Heating	592,610	55%	1,145,569	56%
Facility HVAC	248,601	23%	538,481	26%
Conventional Boiler Use	170,224	16%	306,447	15%
Ventilation	165,198	15%	330,310	16%

END USE	2018 ENERGY SAVINGS (MMBTU)	% OF 2018 TOTAL	2023 ENERGY SAVINGS (MMBTU)	% OF 2023 TOTAL
HVAC Controls	53,730	5%	122,272	6%
Envelope	18,040	2%	32,477	2%
Lighting	-178,091	-17%	-436,739	-21%
Total	**1,070,312**	**100%**	**2,038,818**	**100%**
Percent of Annual Sales Forecast	0.7%		1.3%	

Figure 8-5 shows the estimated 10-year cumulative natural efficiency savings potential broken out by end use across the entire industrial sector. The Process Heating end use shows the largest potential for savings by a wide margin at over 1.1 million MMBtu, or 56% of total savings, in the Constrained UCT Achievable scenario.

Figure 8-5: Industrial Sector 2023 Constrained UCT Achievable Potential Savings by End Use

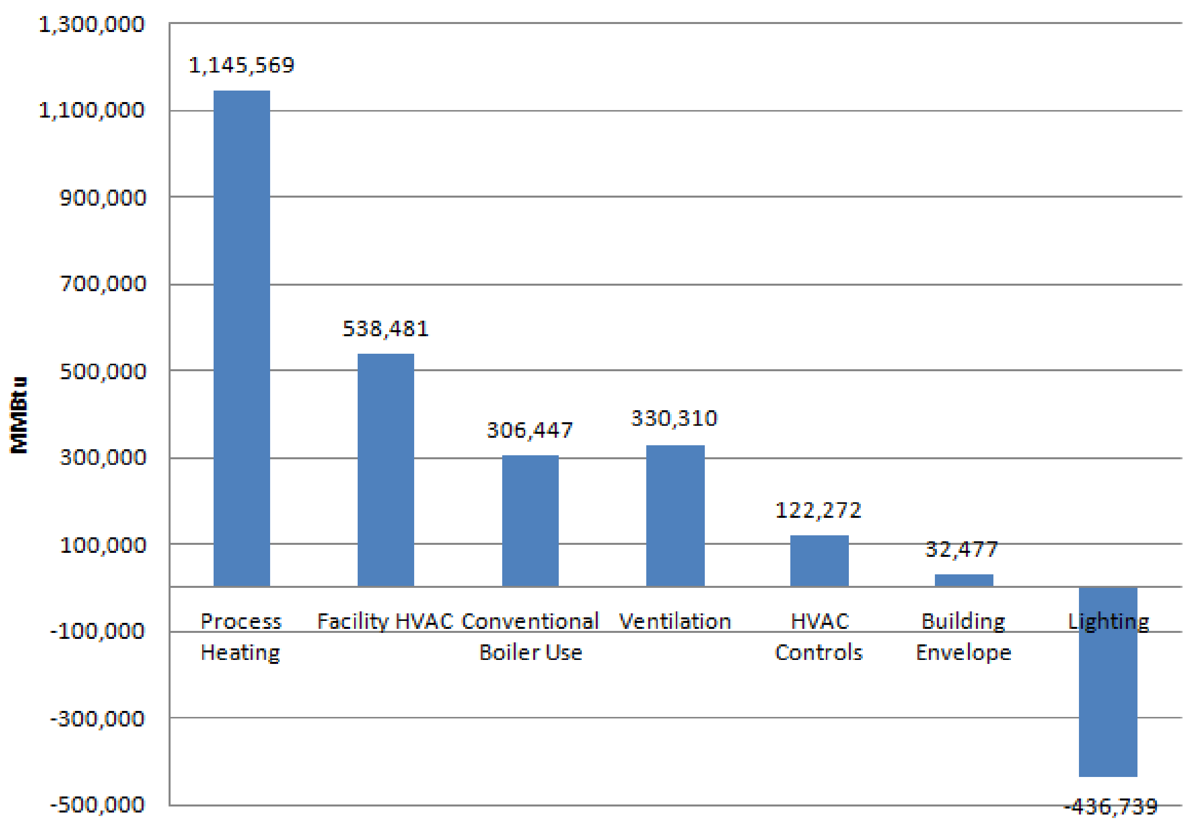
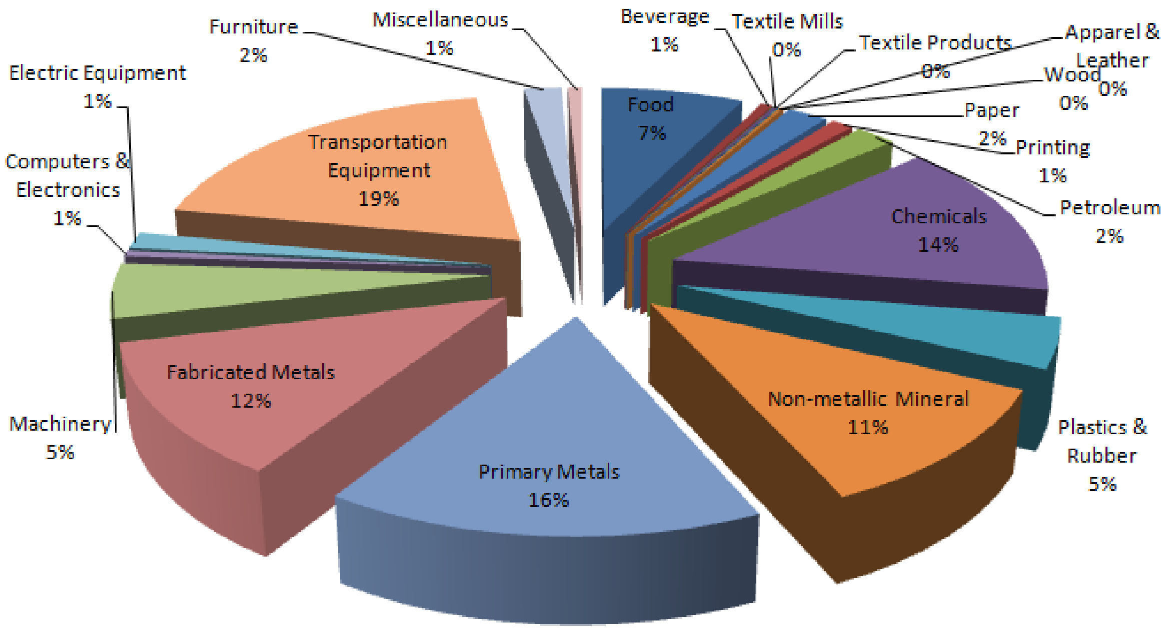


Figure 8-6 shows the breakdown of estimated natural gas savings in 2023 by industry type for the Constrained UCT Achievable scenario. The vast majority of savings come from the transportation equipment, primary metals, chemicals, fabricated metals, non-metallic minerals, and food industries, with all other SIC codes accounting for less than 25% of savings.

Figure 8-6: Industrial Constrained UCT Achievable Potential Savings in 2023 by Industry



8.2.4 Annual Achievable Natural Gas Savings Potential

Tables 8-29, Table 8-30 and Table 8-31 show cumulative energy savings for all achievable scenarios for each year across the 10-year horizon for the study, broken out by end use.

Table 8-29: Cumulative Annual Industrial Natural Gas Savings in the Achievable UCT Potential Scenario, by End Use for Michigan

END USE	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Process Heat	194,815	659,194	1,258,354	1,857,515	2,187,112	2,516,709	2,711,523	2,906,338	3,101,153	3,295,968
Facility HVAC	123,261	332,846	585,591	838,337	1,004,760	1,171,183	1,294,444	1,417,705	1,540,967	1,664,228
HVAC Controls	53,362	213,447	426,895	640,342	747,065	853,789	907,151	960,513	1,013,874	1,067,236
Conventional Boiler Use	59,298	186,773	348,337	509,900	603,287	696,673	755,971	815,268	874,566	933,864
Ventilation	29,577	73,305	124,110	174,915	211,567	248,220	277,797	307,374	336,951	366,527
Envelope	5,655	22,621	45,242	67,862	79,173	90,483	96,138	101,793	107,449	113,104
Lighting	(76,348)	(152,697)	(229,046)	(305,395)	(381,744)	(458,093)	(534,442)	(610,791)	(687,140)	(763,489)
Total	**389,620**	**1,335,488**	**2,559,482**	**3,783,476**	**4,451,220**	**5,118,963**	**5,508,582**	**5,898,201**	**6,287,819**	**6,677,438**
% of Annual Sales Forecast	*0.2%*	*0.8%*	*1.5%*	*2.3%*	*2.7%*	*3.2%*	*3.5%*	*3.8%*	*4.1%*	*4.4%*

Table 8-30: Cumulative Annual Industrial Natural Gas Savings in the Achievable TRC Potential Scenario, by End Use for Michigan

END USE	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Process Heat	161,545	526,116	992,199	1,458,283	1,721,341	1,984,399	2,145,944	2,307,490	2,469,035	2,630,580
Facility HVAC	123,261	332,846	585,591	838,337	1,004,760	1,171,183	1,294,444	1,417,705	1,540,967	1,664,228
HVAC Controls	53,362	213,447	426,895	640,342	747,065	853,789	907,151	960,513	1,013,874	1,067,236
Conventional Boiler Use	59,339	186,936	348,664	510,391	603,859	697,327	756,666	816,004	875,343	934,681
Ventilation	29,577	73,305	124,110	174,915	211,567	248,220	277,797	307,374	336,951	366,527
Envelope	5,655	22,621	45,242	67,862	79,173	90,483	96,138	101,793	107,449	113,104
Lighting	(76,314)	(152,629)	(228,943)	(305,258)	(381,573)	(457,887)	(534,202)	(610,516)	(686,831)	(763,146)
Total	**356,425**	**1,202,642**	**2,293,758**	**3,384,872**	**3,986,192**	**4,587,514**	**4,943,938**	**5,300,363**	**5,656,787**	**6,013,211**
% of Annual Sales Forecast	*0.2%*	*0.7%*	*1.4%*	*2.0%*	*2.5%*	*2.9%*	*3.1%*	*3.4%*	*3.7%*	*3.9%*

Table 8-31: Cumulative Annual Industrial Natural Gas Savings in Constrained Achievable Potential Scenario by End Use for Michigan

END USE	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Process Heat	113,268	232,321	353,177	475,207	592,610	710,404	819,060	927,372	1,036,158	1,145,569
Facility HVAC	62,049	108,569	152,708	197,276	248,601	300,097	359,619	418,953	478,546	538,481
HVAC Controls	26,862	62,395	99,671	137,310	170,224	203,247	229,015	254,701	280,500	306,447
Conventional Boiler Use	34,327	66,867	99,314	132,077	165,198	198,428	231,358	264,183	297,152	330,310
Ventilation	14,889	24,595	33,467	42,426	53,730	65,071	79,354	93,591	107,890	122,272
Envelope	2,847	6,613	10,563	14,552	18,040	21,540	24,271	26,993	29,727	32,477
Lighting	(43,775)	(76,534)	(106,235)	(136,682)	(178,091)	(220,151)	(271,815)	(324,465)	(377,287)	(436,739)
Total	**210,467**	**424,825**	**642,666**	**862,166**	**1,070,312**	**1,278,635**	**1,470,860**	**1,661,328**	**1,852,687**	**2,038,818**
% of Annual Sales Forecast	*0.1%*	*0.3%*	*0.4%*	*0.5%*	*0.7%*	*0.8%*	*0.9%*	*1.1%*	*1.2%*	*1.3%*

8.2.5 Industrial Savings Summary

Table 8-32 provides an end-use breakdown of the industrial natural gas savings potential estimates for technical and economic potential, and each of the three achievable potential scenarios. The table indicates how the savings potential decreases systematically from the technical potential scenario to the Constrained Achievable potential scenario as additional limiting factors such as cost-effectiveness requirements and anticipated market adoption at given funding levels are introduced.

Table 8-32: Natural Gas Potential by End-Use and Measure

End Use	Technical Potential (MMBtu)	Economic Potential -UCT- (MMBtu)	Economic Potential -TRC- (MMBtu)	Achievable Potential -UCT- (MMBtu)	Achievable Potential -TRC- (MMBtu)	Constrained Achievable -UCT- (MMBtu)
Conventional Boiler Use						
Insulate Steam Lines / Condensate Tank	83,878	83,878	83,878	34,652	34,652	11,443
Repair Malfunctioning Steam Traps	419,389	419,389	419,389	173,260	173,260	57,213
High Efficiency Hot Water Boiler (>300,000 Btu/h) (Th. Eff. =85%-90%)	539,964	539,964	539,964	89,229	89,229	37,230
Condensing Boiler (>300,000 Btu/h) (EF>90%) (Th. Eff. >=90%)	32,637	32,637	32,637	7,491	7,491	3,125
Boiler Pipe Insulation	210,169	210,169	210,169	86,826	86,826	28,671
High Efficiency Steam Boiler (>300,000 Btu/h) (Th. Eff. >=80%)	251,634	251,634	251,634	41,582	41,582	17,350
Boiler Reset Controls	511,569	511,569	511,569	211,342	211,342	69,788
Boiler Blowdown Heat Exchanger (Steam)	261,211	261,211	261,211	107,913	107,913	35,634
High Efficiency Hot Water Boiler (<=300,000 Btu/h) (AFUE = 85%-90%)	194,079	194,079	194,079	40,089	40,089	16,727
Boiler Tune-Up	164,071	164,071	166,051	67,782	68,600	22,382
High Efficiency Steam Boiler (<=300,000 Btu/h) (AFUE >=82%)	284,426	284,426	284,426	47,001	47,001	19,611
Condensing Boiler (<=300,000 Btu/h) (AFUE>90%)	116,314	116,314	116,314	26,696	26,696	11,138
Boiler O2 Trim Controls	78,224	0	0	0	0	0
Electronic Parallel Positioning Controls (linkage less)	77,830	0	0	0	0	0
Process Heating						
Regenerative Thermal Oxidizer vs. STO	815,809	815,809	815,809	337,031	337,031	111,776
Boiler Pipe Insulation	848,957	848,957	848,957	350,725	350,725	116,317
High Efficiency Hot Water Boiler (>300,000 Btu/h) (Th. Eff. =85%-90%)	2,120,091	2,120,091	2,120,091	350,345	350,345	146,812
Condensing Boiler (>300,000 Btu/h) (EF>90%) (Th. Eff. >=90%)	376,904	376,904	376,904	86,505	86,505	36,250

END USE	TECHNICAL POTENTIAL (MMBTU)	ECONOMIC POTENTIAL -UCT- (MMBTU)	ECONOMIC POTENTIAL -TRC- (MMBTU)	ACHIEVABLE POTENTIAL -UCT- (MMBTU)	ACHIEVABLE POTENTIAL -TRC- (MMBTU)	CONSTRAINED ACHIEVABLE -UCT- (MMBTU)
High Efficiency Steam Boiler (>300,000 Btu/h) (Th. Eff. >=80%)	989,276	989,276	989,276	163,478	163,478	68,505
Boiler Reset Controls	1,992,335	1,992,335	1,992,335	823,083	823,083	272,974
Boiler Tune-Up	729,934	729,934	729,934	301,554	301,554	100,010
Regenerative Thermal Oxidizer vs. CTO	527,344	527,344	527,344	217,859	217,859	72,252
Improved Sensors & Process Controls	1,610,620	1,610,620	0	665,387	0	220,674
Boiler O2 Trim Controls	310,217	0	0	0	0	0
Electronic Parallel Positioning Controls (linkage less)	308,653	0	0	0	0	0
Waste-Heat Recovery	818,927	0	0	0	0	0
Facility HVAC						
Stack Heat Exchanger (Condensing Economizer)	570,220	570,220	570,220	208,558	208,558	59,885
Stack Heat Exchanger (Standard Economizer)	277,633	277,633	277,633	101,544	101,544	29,158
High Efficiency Furnace (<=300,000 Btu/h) (AFUE >=92%)	1,740,448	1,740,448	1,740,448	353,649	353,649	128,309
Infrared Heater (low intensity - two stage)	1,459,915	1,459,915	1,459,915	314,096	314,096	113,958
Direct Fired Make-up Air System	1,512,309	1,512,309	1,512,309	553,127	553,127	158,825
Gas Unit Heater - Condensing	801,522	801,522	801,522	133,253	133,253	48,346
Heat Recovery: Air to Air	470,878	0	0	0	0	0
Insulate and Seal Ducts (New Aerosol Duct Sealing)	790,787	0	0	0	0	0
Building Envelope						
Wall Insulation R-7.5 to R13	159,032	159,032	159,032	7,733	7,733	2,220
Below Grade Insulation	7,912	0	0	0	0	0
Ceiling Insulation R-11 to R-42	415,134	415,134	415,134	105,371	105,371	30,256
Energy Efficient Windows	1,896,822	0	0	0	0	0
Roof Insulation R-11 to R-24	249,483	0	0	0	0	0
Ventilation						
Improved Duct Sealing	653,831	653,831	653,831	225,009	225,009	81,636

END USE	TECHNICAL POTENTIAL (MMBTU)	ECONOMIC POTENTIAL -UCT- (MMBTU)	ECONOMIC POTENTIAL -TRC- (MMBTU)	ACHIEVABLE POTENTIAL -UCT- (MMBTU)	ACHIEVABLE POTENTIAL -TRC- (MMBTU)	CONSTRAINED ACHIEVABLE -UCT- (MMBTU)
Destratification Fan	239,535	239,535	239,535	141,519	141,519	40,636
HVAC Controls						
EMS Optimization	127,103	127,103	127,103	78,245	78,245	22,467
EMS install	1,180,814	1,180,814	1,180,814	726,916	726,916	208,727
Programmable Thermostats	489,024	489,024	489,024	262,075	262,075	75,252
Lighting						
Induction Fluorescent	-1,533,839	-1,516,602	-1,486,891	-763,489	-763,146	-436,739
Total	**26,183,022**	**21,190,526**	**19,611,597**	**6,677,438**	**6,013,211**	**2,038,818**
% of Annual Sales Forecast	**17.1%**	**13.9%**	**12.8%**	**4.4%**	**3.9%**	**1.3%**
Note: Measures in the above Table with "0" achievable potential are ones that did not pass the SCT Test.						

Table 8-33 provides a list of the Top 10 industrial natural gas savings measures for the Achievable UCT scenario. The table provides the measures ranked according to the electric savings potential. The column to the far right shows the results of the measure level cost-effectiveness screening test using the UCT to screen the measures.

The Top 10 measures combine to yield an estimated 4,775,915 MMBtu savings. This accounts for 64% of the total industrial electric savings in the Achievable UCT scenario.

Table 8-33: Top 10 Industrial Gas Savings Measures in the Achievable UCT Scenario

MEASURE	2023 ENERGY (MMBTU)	% OF SECTOR SAVINGS	UCT RATIO
1. Boiler Reset Controls	823,083	11%	2.59
2. EMS Install	726,916	10%	18.81
3. Improved Sensors & Process Controls	665,387	9%	1.20
4. Direct Fired Make-up Air System	553,127	7%	1.99
5. High Efficiency Furnace (<=300,000 Btu/h) (AFUE >=92%)	353,649	5%	5.69
6. Boiler Pipe Insulation	350,725	5%	4.00
7. High Efficiency Hot Water Boiler (>300,000 Btu/h) (Th. Eff. =85%-90%)	350,345	5%	2.11
8. Regenerative Thermal Oxidizer vs. STO	337,031	5%	17.61
9. Infrared Heater (low intensity - two stage)	314,096	4%	5.61
10. Boiler Tune-Up	301,554	4%	2.29
Total	**4,775,915**	**64%**	

8.3 ACHIEVABLE POTENTIAL BENEFITS & COSTS

The tables below provide the net present value (NPV) benefits and costs associated with the three achievable potential scenarios for the industrial sector at the 5-year and 10-year periods. Tables 8-33 and 8-34 compare the 5 and 10 year NPV benefits and costs associated with the Achievable UCT and Achievable TRC Scenarios. Both the UCT and TRC scenario benefits include avoided energy supply and demand costs, while the Achievable TRC scenario benefits also include water savings benefits. The NPV costs in the Achievable UCT scenario includes only program administrator costs (incentives paid, staff labor, marketing, etc.) whereas the Achievable TRC scenario costs include both participant and program administrator costs.

Table 8-34: 5-Year Benefit-Cost Ratios for Achievable Potential Scenarios – Industrial Sector Only

5-YEAR	NPV BENEFITS	NPV COSTS	B/C RATIO	NET BENEFITS
Achievable UCT	$1,460,878,857	$458,092,836	3.19	$1,002,786,022
Achievable TRC	$1,586,366,858	$490,194,989	3.24	$1,096,171,869

Table 8-35: 10-Year Benefit-Cost Ratios for Achievable Potential Scenarios– Industrial Sector Only

10-YEAR	NPV BENEFITS	NPV COSTS	B/C RATIO	NET BENEFITS
Achievable UCT	$2,475,174,491	$697,726,700	3.55	$1,777,447,791
Achievable TRC	$2,710,700,750	$795,215,890	3.41	$1,915,484,860

Tables 8-35 and 8-36 compare the NPV benefits and costs associated with the Achievable UCT and Constrained UCT Scenarios. Both scenarios compared the benefits and costs based the UCT. However the constrained scenario's 2% of revenue spending cap on DSM results in reduced program participation and overall NPV benefits.

Table 8-36: 5-Year Benefit-Cost Ratios for Achievable Potential Scenarios – Industrial Sector Only

5-YEAR	NPV BENEFITS	NPV COSTS	B/C RATIO	NET BENEFITS
Achievable UCT	$1,460,878,857	$458,092,836	3.19	$1,002,786,022
Constrained UCT	$624,960,526	$186,886,891	3.34	$438,073,636

Table 8-37: 10-Year Benefit-Cost Ratios for Achievable Potential Scenarios– Industrial Sector Only

10-YEAR	NPV BENEFITS	NPV COSTS	B/C RATIO	NET BENEFITS
Achievable UCT	$2,475,174,491	$697,726,700	3.55	$1,777,447,791
Constrained UCT	$1,264,708,643	$332,546,178	3.34	$932,162,465

Year by year budgets for all three scenarios, broken out by incentive and administrative costs are depicted in Tables 8-37 through 8-39. Table 8-40 shows the revenue requirements for each scenario as a percentage of forecasted sector sales.

Table 8-38: Annual Program Budgets Associated with the Achievable UCT Scenario (in millions)

ACHIEVABLE UCT	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Incentives	$51.2	$76.5	$88.9	$88.5	$62.2	$62.4	$49.1	$49.2	$49.8	$51.5
Admin.	$21.1	$31.3	$36.2	$36.0	$25.5	$25.6	$20.3	$20.3	$20.6	$21.3
Total Costs	*$72.4*	*$107.8*	*$125.1*	*$124.5*	*$87.7*	*$88.0*	*$69.4*	*$69.5*	*$70.4*	*$72.8*

Table 8-39: Annual Program Budgets Associated with the Achievable TRC Scenario (in millions)

ACHIEVABLE TRC	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Incentives	$35.5	$46.8	$52.5	$52.6	$41.8	$42.1	$39.2	$36.7	$37.5	$39.7
Admin.	$14.9	$19.4	$21.7	$21.7	$17.4	$17.5	$15.3	$15.3	$15.7	$16.5
Total Costs	*$50.4*	*$66.2*	*$74.2*	*$74.3*	*$59.1*	*$59.6*	*$55.5*	*$52.0*	*$53.1*	*$56.2*

Table 8-40: Annual Program Budgets Associated with the Constrained UCT Scenario (in millions)

CONSTRAINED UCT	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Incentives	$28.8	$29.2	$29.7	$30.2	$30.6	$31.1	$31.5	$32.0	$32.6	$33.1
Admin.	$11.9	$12.0	$12.3	$12.5	$12.6	$12.8	$13.0	$13.2	$13.4	$13.6
Total Costs	*$40.7*	*$41.2*	*$42.0*	*$42.7*	*$43.2*	*$43.9*	*$44.5*	*$45.2*	*$46.0*	*$46.7*

Table 8-41: Revenue Requirements per Scenario as a % of sector sales

	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Achievable UCT	3.5%	5.2%	5.9%	5.8%	4.0%	3.9%	3.0%	3.0%	3.0%	3.1%
Achievable TRC	2.5%	3.4%	3.7%	3.7%	2.8%	2.8%	2.5%	2.3%	2.4%	2.4%
Constrained UCT	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%

APPENDIX A: RESIDENTIAL MEASURE DETAIL

APPENDIX B: COMMERCIAL MEASURE DETAIL

APPENDIX C: INDUSTRIAL MEASURE DETAIL

APPENDIX D: GLOBAL ASSUMPTIONS

MICHIGAN ELECTRIC AND NATURAL GAS ENERGY EFFICIENCY POTENTIAL STUDY

Prepared for:

MICHIGAN PUBLIC SERVICE COMMISSION

Consumers Energy
Count on Us

DTE Energy

GDS Associates, Inc.
Engineers and Consultants

Prepared By:

GDS ASSOCIATES, INC.
1850 PARKWAY PLACE
SUITE 800
MARIETTA, GA 30067
770.425.8100
770.426.0303 (FAX)
WWW.GDSASSOCIATES.COM